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A SYSTEMS APPROACH TO INTEGRATING THE H-46 OPERATIONAL FLIGHT T--ETC(U)

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THESIS

6 A SYSTEMS APPROACH TO INTEGRATING THE H-46 OPERATIONAL FLIGHT TRAINER (OFT) DEVICE 2-F117B INTO THE H-46 FLIGHT TRAINING PROGRAM.

by

10 Robert Dale Smith

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increased use of flight simulators. With the introduction of device 2-F117B, the Navy H-46 community will have a state-of-the-art simulator to employ in their training programs. With this introduction, the training program must become responsive to factors influencing training effectiveness and transfer of training. This report explores factors influencing training effectiveness and applies them to a proposed flight training syllabus for the H-46 fleet replacement squadrons.

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A Systems Approach to Integrating
the H-46 Operational Flight Trainer (OFT)
Device 2-F117B into the H-46 Flight
Training Program

by

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requirements for the degree of

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ABSTRACT

The increasing annual costs associated with helicopter fleet replacement squadron training, along with the shrinking fiscal budgets, has necessitated the use of flight simulators as integral parts of many flight training programs. The realization that the simulator coupled with a well designed training program provides a training platform with more training potential than the traditional approach (aircraft), is also a factor which has stimulated the increased use of flight simulators. With the introduction of device 2-F117B the Navy H-46 community will have a state-of-the-art simulator to employ in their training programs. With this introduction, the training program must become responsive to factors influencing training effectiveness and transfer of training. This report explores factors influencing training effectiveness and applies them to a proposed flight training syllabus for the H-46 fleet replacement squadrons.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

I. INTRODUCTION

The incorporation of flight simulators into Navy helicopter flight training has greatly expanded in the last five years and in all likelihood will continue to expand in the future. There are numerous reasons for this increase in the use of flight simulators in aviation, especially in the fixed winged community. Hopkins (1975), has claimed that the advantages of flight simulators frequently cited for training are: cost, training effectiveness and efficiency, aircraft availability, and safety.

The problems associated with aircrew flight training, with the adjunct of flight simulators, are complex, but not unsolvable. Factors to consider in developing a flight training program include:

1. Identifying the sequence number and type of sorties to be flow in the simulator instead of the aircraft.
2. Training the flight instructor as an effective training manager.
3. Effectively applying learning theory to the training program.
4. Identifying the sequence of modular components which the pilot under instruction (PUI) should proceed.

Each of the different aviation communities (helicopter, transport, fighter, attack) have requirements peculiar to their own mission and training environment, and therefore approach the above factors differently. However, a great

majority of flying tasks, especially within specific communities, can be generalized and therefore a common approach to training skills may be applied.

Though the major purpose of this report is to propose a training program utilizing a flight simulator (device 2-F117B) for the Navy H-46 community, theories and approaches taken to integrate the simulator and the aircraft into a viable training package will certainly be beneficial to other aviation squadrons. Fleet Replacement Squadron (FRS) training within the helicopter community of the Navy have flying tasks which procedurally are quite similar. While each warfare specialty (HC, HS, HSL, HM) differs in mission requirements and capabilities and therefore have different criteria for training in these areas, a large percentage of FSR training falls in common mission areas such as Familiarization, Instrument, Night, Ship, Rough Terrain and External Cargo (HC-3 Instruction 1500.1a; SH-2F Pilot Aircrew Training Curriculum outline; H-3 Pilots Curriculum outline). A common approach to a training program can be developed for these areas, which can be modeled after the training proposed for the H-46 community, which is presented in this paper.

A. BACKGROUND

The man/machine interface has presented countless problems ever since the advent of sophisticated mechanization. The problems associated with training, costs, safety, efficiency and effectiveness, as they interrelate with the man/machine

interface are apparent in past and present systems and will undoubtedly plaque future designers and operators. Probably nowhere is the problem more apparent than in aviation. Consequently it has been in aviation where considerable time and funds have been utilized to try and solve these man/machine interactive problems. The aviation community has innovated the use of simulators as a vehicle in which a partial solution to these problems might evolve.

Simulation, a technique wherein a controlled environment is used to imitate and reproduce the actual operating environment, is an area where there has been considerable research and technological advancement made in the past decade (Subcommittee on Research and Development, 1976). With advances in simulator technology, state-of-the-art simulators are very reasonable approximations of the systems they simulate. These aircraft counterparts imitate or duplicate features of the actual flight platform for the expressed purpose of (controlled) training of specific flying skills required in the aircraft mission environment [Erickson, et al., 1972].

The use of flight simulators as training devices in aviation is not new. Valverde (1972) has documented that in 1910, in Europe, two rather crude flight simulators were used in pilot training programs, and in 1917 the French developed and used a training device which produced variation of response and feel with assumed speed. The device also incorporated an engine noise and a simple visual system. In

the United States Edwin Link developed the first flight simulator in 1929. Subsequent to this and during the pre-World War Two era, there was a period of accelerated aviation progress in which the introduction of instrument flying took place. To cope with the problem associated with training pilots safely in instrument flying techniques, extensive research and development of ground based instrument trainers was undertaken. During World War Two and up to the present time, simulators have developed into precisely engineered devices with complex visual and motion systems capable of realistically imitating and reproducing flight parameters for nearly all flight situations [Valverde, 1973].

Even with these advances in the technology and use of flight simulators, the role of flight simulators in many training programs has not changed significantly. In too many instances, existing training programs are simply retrofited with flight simulators. Little thought has been given to exploiting the unique features a simulator incorporates that will enhance ones ability to train (mold behavior) individual pilots [Caro, 1973, 1976a, 1977; Caro and Prophet, 1973].

Essentially the wrong approach has been taken in the employment of flight simulators in flight training programs. Instead of retrofiting existing programs, efforts should be directed towards designing new flight training programs which will be capable of capitalizing on the multitude of training advantages flight simulators are capable of providing.

B. BENEFITS OF SIMULATION

The increasing role of flight simulation, in the military is due primarily to the following factors:

1. Costs
2. Safety
3. Efficiency
4. Effectiveness

This increased use of flight simulators is not solely due to their own training merits, but to the realization of basic disadvantages in using actual aircraft as the vehicle for training. The flight simulator will be able to minimize the time spent in the aircraft learning flying skills and procedures. This will essentially transfer training hours from an inefficient environment (aircraft) to a more productive efficient training environment (simulator); where the level of stress and workload can be controlled to meet the particular requirements of each pilot in the development of the requisite flight skills.

1. Costs

The cost of flying aircraft in the military in 1975 was $2.7 billion for 6.4 million flying hours [Orlanski and String, 1977] or approximately $438 per flight hour. Therefore, the major driving force behind the utilization of flight simulators in aircrew training has been cost. The most frequently cited guidance to the Department of Defense was mandated by the Office of Management and Budget (OMB), 1973, to reduce total military flying hours by 25 percent in the early

eighties [Subcommitte on Research and Development, 1976]. It should be pointed out that there are no known studies which would support a flight time reduction figure of this magnitude. Testimony given by Dr. John L. Allen before the Subcommittee of Research and Development, suggests that this figure was one the OMB picked out of the sky, that was felt to be reasonable. The respective services are somewhat more conservative in their estimates. The Army has stated they cannot meet this figure. The Navy estimates 13 percent by fiscal 1989, and the Air Force has estimated a 20 percent reduction by 1985 [Subcommittee on Research and Development, 1976]. The literature does not report any study of a flight simulator subjected to a rigorous, objective, cost evaluation; the direct cost savings through the integration of flight simulators is well documented, as can be seen from Fig. 1. When evaluating operating cost alone it is obvious that it costs less per hour to operate a flight simulator than the counterpart aircraft. By using a simulator to aircraft operating cost ratio, most programs have ratios ranging from 5 to 20 percent with a median value of 12 percent [Orlansky and String, 1977].

In addition to direct savings offered by the use of flight simulators, indirect savings can also be anticipated. Reduced wear and tear on the aircraft through reduced aircraft usage as well as possible reduced loss of personnel and equipment due to accidents may well result. The use of

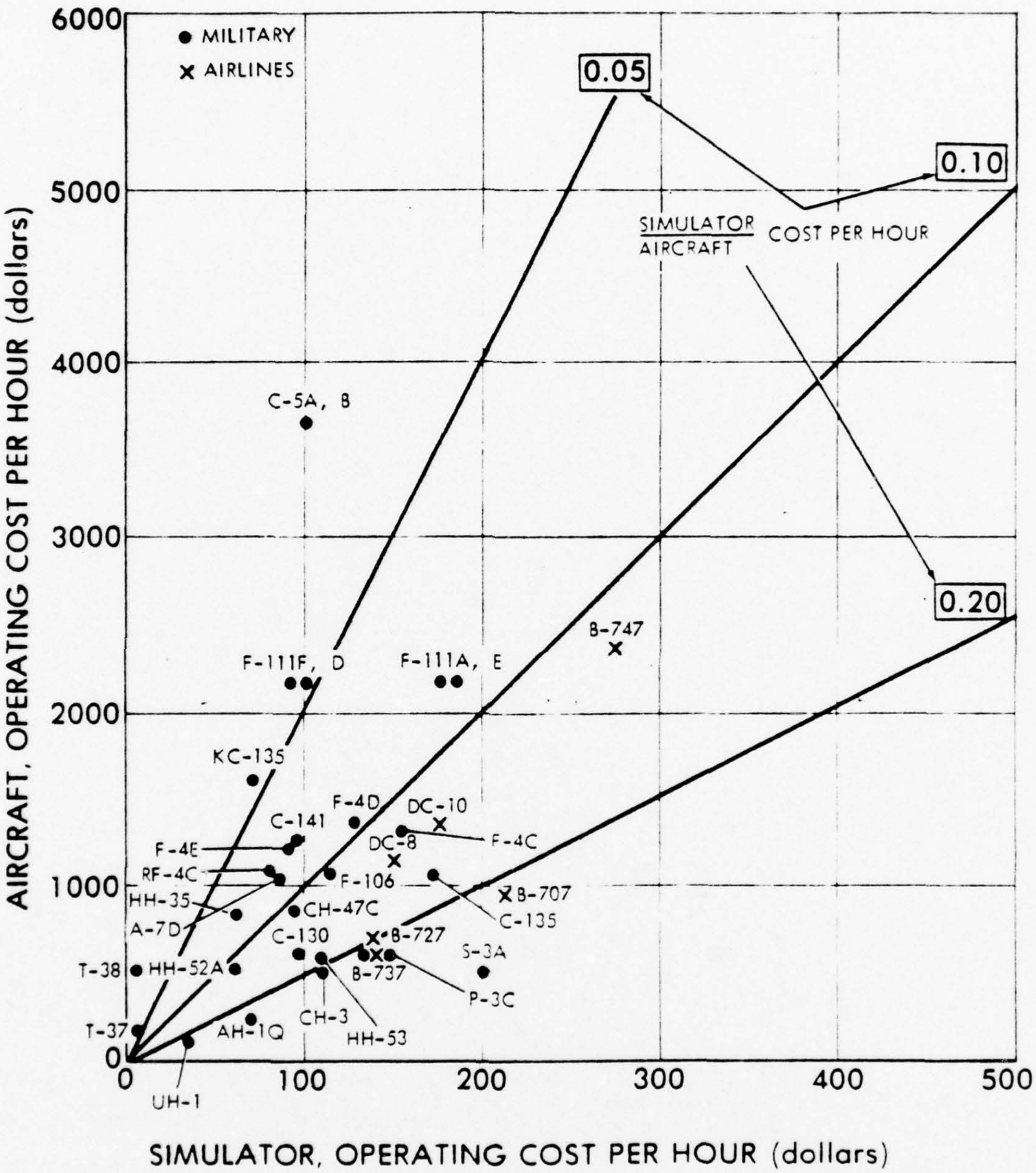

Figure 1 - Variable Operating Costs per hour for 33 Simulators and Aircraft, FY 1975 and FY 1976
Source: Orlansky and String (1977)

simulators reduces other costs such as non-recoverable weapons systems, and target and weapon range cost. Increased effective use of runways and airspace will result from expanded utilization of simulators. A spin-off from this will be attendant savings in support facilities, energy needs, and the wages of personnel needed to operate them. The indirect cost savings are numerous and those listed above are possibly a small subset. As yet there are no formal studies which demonstrate or quantify indirect savings factors.

2. Safety

There can be little question as to the possibility of improved safety to any training program which utilizes flight simulators. Flight simulators offer both direct and indirect safety features to a training program. Direct features allow control over a wide variety of malfunctions which allows the student pilot to experience the consequences of improper performance. Simulators directly allow aircrews to train in flight missions and emergency conditions which are too dangerous to attempt in the aircraft.

Presently, the Federal Aviation Agency (FAA) and other federal agencies are concerned over the nations congestion, utilization and management of airspace. It could be postulated that this overloading of airport facilities, controllers, and airspace, could lead to an increase in aircraft accidents and incidents. Indirectly, through the utilization of simulators, many hours spent in the aircraft for training and transitional

flights will be reduced by being redirected to the flight simulator. Through this reduction of flight hours the impact of congestion and overload as contributing factors of aircraft accidents may possibly be reduced.

3. <u>Efficiency</u>

Flight simulators are able to utilize any given block of time, for training purposes, more efficiently than are the aircraft they simulate. It is possible, in a simulator training environment, to insert conditions for training a specific task without regard to the preceding flight requirements leading up to the specific task. As an example: if a student was encountering difficulty with the task of landing an aircraft, just that portion of the flight could be practiced until criterion was met, without regard to the other portion of the flight. This procedure could not be followed if the aircraft was used for training the landing task, and inefficient utilization of time could occur by practicing those tasks (preceding landing, e.g., crosswind, downwind, baseleg) which may have already been mastered.

Simulators can also provide efficient use of training time by being impervious to factors such as weather, time of day, availability of aircraft and target areas, as well as the availability of ship landing platforms. Noise abatement regulations exist at many airports and densely populated areas. Training can be performed in simulators without impacting these areas.

4. Effectiveness

Many studies over the past 35 years indicate that flight simulators provide an effective medium to train pilots and aircrews in requisite flying skills [Orlansky and String, 1977]. Effectiveness of flight simulators can be viewed in either of two ways:

1. Training Effectiveness.
2. Cost Effectiveness

Recently Orlansky and String (1977) have proposed a number of conclusions about the training effectiveness of flight simulators. The following conclusions are considered to be of primary importance:

1. Simulators are most effective as training devices where the task to be trained involves following precise procedures such as instrument flying.
2. The manner in which flight simulators are utilized in a given training environment will dictate the degree of effectiveness it will be able to provide as a training device.

Factors influencing training effectiveness include the syllabus, the feedback given the student pilot, and the manner in which the instructor pilots are trained and utilized. A variety of transfer of training formulas are presently the means by which a measure of effectiveness is given to a specific simulator training system. This topic of transfer of training will be taken up in more detail in a later section.

A major question confronting simulator training programs is in what quantity and in what mix, should either the part-task trainer, the simulator, or the aircraft be employed as the training vehicle. Part-task trainers are generally referred to as procedural trainers. The devices can either be cardboard mockups, salvaged cockpits or actual production models. The three types of procedural trainers share a common attribute in that they provide students the opportunity to become familiar with, and to develop, limited proficiency in the operation of a particular flight function. These procedural trainers do not respond to control inputs, and simulate the actual aircraft only as far as physical configuration is concerned (displays and controls, etc.). Part-task trainers do not possess any motion or visual fidelity and therefore will not be a significant substitute for actual flight time, but the potential contribution to the total training program is quite apparent. Diehl and Ryan (1977) have ascertained that a well structured approach to flight training implies the use of part-task trainers.

The key issue in the design and use of synthetic flight trainers is no longer simply a question of whether a given feature or procedure is effective in yielding positive transfer, it must also be cost-effective [Roscoe, 1974]. There are no known studies which would indicate that any presently operational flight simulators, used in military training, which are not cost-effective. As mentioned earlier,

Orlansky and String (1977) have indicated that present flight simulator hourly operating costs are 5 to 20 percent of the hourly operating cost of the aircraft they simulate. Part-task trainers, mentioned above, are the least expensive to operate.

Incremental cost effectiveness is a tool which may aid the training manager in constructing a cost effective training system. First introduced by Roscoe (1971, 1972) and later supported by Povenmire and Roscoe (1973) and Roscoe (1974), incremental cost effectiveness indicates that successive increments of simulator training, on any flight task, will yield diminishing transfer of training. At some point the incremental transfer will save an increment of flight time so small that it would cost less than the next hour in the simulator. Training, at this point of the flight task would be ineffective in terms of costs. These points could signal the training manager when the student should shift from a part-task trainer to a full mission simulator, and hence to the aircraft. The only empirical study done, using an incremental approach, was conducted by Povenmire and Roscoe (1973). Although a simplistic experimental design coupled with a crude simulator (Singer-Link CAT-1) and a simple airplane (Cherokee 140) were used, it appeared that the approach might be useful in designing a complex, state-of-the-art flight training system.

C. DISADVANTAGES OF FLIGHT SIMULATORS

It might appear from the foregoing discussion that the present day full mission flight simulator provides reasonable solutions to the many problems confronting military flight training. Some authors in the literature suggest the possibility of reducing actual flight time anywhere from 50 to 70 percent. It is worth pointing out that these reduction figures are modeled after the success of the airlines. Military aviation and airline aviation, except possibly for transport flying, are not equitable. Not only are the experience levels of the pilots different but the mission categories are not comparable.

There are at least three disadvantages to the present and future predicted use of flight simulators. First, flight simulators will never be able to adequately and realistically duplicate all flight conditions that the aircraft it simulates operates in and therefore will not be able to produce the motivation and stress provided by actual flight. It is important that military pilots be able to function appropriately and skillfully under high stress and workload flight environments. It is equally important that the commanders of squadrons know who can and cannot perform under these conditions. Only in the aircraft does the pilot confront the ultimate consequence of a mistake, and is therefore the only realistic medium where a pilot's performance under stress can be observed.

Secondly, it should be realized that when military pilots are operating in their mission environment, there are a number of support facilities necessary for the successful completion of the mission. With the utilization of simulators and therefore the reduction in flight time, maintenance and supply systems will be operating at reduced levels. It has yet to be determined at what levels these support facilities must be operated to maintain combat readiness.

Lastly, the military presently is having difficulty with pilot retention. It can be hypothesized that one of the primary factors that motivates an individual to become a pilot, is that one will actually fly an airplace and experience all the sensations involved with flying. Given a choice between flying a simulator or the aircraft, it is certain the aircraft will be chosen. Pilots become pilots to fly aircraft, not simulators, and if through simulation the already minimal flight time is reduced further, it will make the job of recruiting and maintaining appropriate pilot manning levels in the military that much more difficult.

D. DESCRIPTION/MISSION OF THE H-46

The H-46 (models A, D, and F) is a twin-turbine powered, dual-piloted, tandem-rotor helicopter, designed by the Boeing Company, Vertol Division. The HH-46A is assigned to Naval Air Stations and is used for day/night search and rescue operations. The primary missions of the UH-46D/A models are vertical replenishment and utility. The CH-46/F,

used by the Marines, has the primary mission of rapidly dispersing combat troops, support equipment, and supplies from amphibious assault landing ships, and establishing airfields to advanced bases in undeveloped areas having limited maintenance and logistic support under all-weather conditions (instrument flight), day or night.

II. STATEMENT OF THE PROBLEM

The introduction of the H-46 helicopter occurred in the Navy's inventory in the early 1960's and ever since a need has existed for a realistic and safe environment in which to train fleet replacement pilots. Learning to fly a helicopter is a unique experience in that inadequate preparation for the task can lead to more than an unsatisfactory grade. With this in mind, and the increased emphasis on simulation the Navy contracted with Reflectone Inc., to develop a full mission flight simulator which could provide the necessary training platform for the Navy and Marine Corps' H-46 helicopter aircrews. Presently there is one flight trainer (Device 2-F117) in operation at the Marine Corps Air Station, New River, North Carolina. This trainer simulates the CH-46F used by the U.S. Marine Corps. The Navy presently operates H-46A and D models, and consequently, the device 2-F117 can be modified and designated 2-F117B to simulate the "D" model H-46.

Justification for the procurement of device 2-F117B is that it should be capable of training H-46 crew members in the most realistic, cost effective manner. The problem areas that must be addressed are:

1. How will the addition of device 2-F117B affect FRS flight training?
2. How should the device be utilized in the training system to insure the most effective training possible?

This report will attempt to utilize lessons learned from past and present training systems to aid in the transition when the Navy H-46 helicopter squadrons receive device 2-F117B. One ineffective use of flight simulators in many present day training systems is that rather than risk less than perfect transfer, the aircraft is still preferred over the use of modern day simulators for teaching flying skills. This is to be expected. While engineering technology and computer science have made great strides in providing for fidelity of visual, motion and handling characteristics, few advances in exploring the use of a modern day simulator as an ideal teaching device have been made [Caro, 1977; Baily, 1978]. As a result of this neglect there is a natural tendency for an experienced instructor pilot to use a simulator much like the aircraft would be used, thus over looking the fact that the aircraft itself is certainly a less than perfect setting for maximizing the requisite flying skills.

Those principally responsible for the design of simulators have been engineers and pilots and it is in this light that flight simulators are built as realistic as possible. This philosophy is consistent with the identical elements theory of transfer pioneered by Thorndike, but the approach is also a cover-up for our ignorance about transfer and therefore we have made costly devices as realistic as we can in hopes of gaining as much transfer as possible [Adams, 1972]. The real goal of any flight simulator training program should be

to enhance psychological fidelity. Presently in simulator design circles, simulators are designed to simulate rather than to train [Caro, 1977].

III. METHODOLOGY

A. PROCEDURE

An extensive literature review was conducted in order to forecast the possible effects device 2-F117B would generate on aircrew training in the Navy H-46 helicopter community. Factors considered were those associated with simulator design characteristics, training effectiveness, transfer of training and measures of effectiveness. Device 2-F117B was then evaluated in terms of its fidelity, training features and proposed role it would have in the H-46 training syllabus. Estimation of simulator effectiveness were calculated by using indices such as Transfer Effectiveness ratio (TER), a topic to be covered in a later section.

Through analysis of training features incorporated in device 2-F117B, details in a later section will propose substitution of particular aircraft sorties by simulator sorties. This proposed substitution should allow the integration of device 2-F117B into the H-46 training system as an effective cost and training component.

B. MODEL

The model used to examine factors necessary in the establishment of an effective and viable flight simulator training program are those instituted by Jeanthau (1971) and later expanded by Caro (1976 and 1977). A three phase model will be presented as follows:

1. An analytical framework composed of fidelity of the device, and elements incorporated that effect transfer of training.
2. A study of the syllabus used and how factors affecting learning may be employed in the flight simulator.
3. Comparison of different means by which the device may be utilized.

Since the device is not operational as of yet, the model will provide only a qualitative assessment of the training system effectiveness. It is only after the device is operational that through appropriate data analysis, experimental design, and control, will a credible quantitative model be feasibly employed to meet present and future training requirements.

C. PROBLEMS ENCOUNTERED

There is a dearth of information in the literature covering factors which influence simulator training effectiveness. Individuals in the simulator industry; researchers, contractors, and users, have not amply documented or disseminated information about the design of simulators, or the training programs in which they are incorporated. For this reason a conceptual model, which would present research accomplished by designers and users amenable to generalized problem solutions, is lacking. Therefore, training managers, faced with either incorporating a flight simulator into an existing system or designing a new one, have no theoretically acceptable

design models to follow, and no measures of effectiveness with which to compare their programs [Caro, 1976a]. Only recently have these problems received specific attention, and even then the influence of some factors have only been hypothesized. Without a broad data base, conclusions drawn about quantitative assessments of the influence of suspected factors on the study of different methodologies are difficult to generalize. Conclusions drawn from the literature on theories concerning simulator effectiveness have ended in a great deal of contradiction. As a result, the training model presented for the H-46 training system and device 2-F117B, is in most cases, suggestive in nature and based upon the experience of the author, as a former H-46 Aircraft Commander, Instructor Pilot, Assistant Natops Evaluator and Post-Maintenance Check Pilot; along with the consensus of theories extrapolated from notable authorities on the subject of flight simulator training.

IV. TRAINING

As mentioned in the problem statement section there has been a tendency in the simulator industry to ignore the principles of training and/or learning as significant factors in simulator design, and instead, to focus the major attention on perpetuating fidelity characteristics [Valverde, 1973; Williges, 1973; Baily et al., 1978; McGuiness et al., 1978; Muth et al., 1978; Caro, 1973a, 1973b, 1976, 1977]. Training, the reason for the simulators existance, appears to have been forgotten, which may be due to the fact that no one really knows how to train in simulators [Caro, 1976a]. Until recently very little had been expended on efforts to develop a technology of simulator training. This is unfortunate, for if one would analyze the problems associated with simulator and training system design, one could reasonably accept the hypotheses that training program design, coupled with optimizing training profiles and techniques, would provide the key to achieving real gains in training efficiency.

A. TRAINING PRINCIPLES APPLIED TO SIMULATORS

Fortunately a number of individuals [Baily, 1978; Hughes, 1978; Bryan and Regan, 1972; Kinkade and Weaton, 1972] have forseen this neglect in simulator and training system design and are beginning to unite learning theory with the design of flight simulators as a means of enhancing the performance of aircrews. The following section is a summary of their

efforts and will be concerned with those principles of learning theory which actually apply to design features of flight simulators:

(1) <u>Prompting, Cuing and Fading</u>: Signals which indicate a specific action should take place and direct a student pilot to perform an action at a given time is a learning technique known as prompting. During the early stages of learning the requisite behavior may be weak and may not readily occur when it should, so frequent additional stimuli, are needed to help initiate a response. As training proceeds and desired behavior begins to occur regularly, Bryan and Reagan (1972) suggest that the prompts be momentarily delayed. This would allow the student pilot the opportunity to perform the required action before being prompted.

There is a subtle distinction made by Bryan and Reagan (1972) between prompting and cuing. They define a cue as a simple signal which specifies an action time and therefore a cue is much less directive than a prompt. In either case, the prompt or cue, whichever is used to solicit required behavior should gradually be withdrawn as the desired behavior is able to stand alone under natural environmental conditions. This learning technique is known as fading [Baily et al., 1978]. The autorotation maneuver performed in the H-46 helicopter provides an example of the prompting, cueing and fading principles where an experineced pilot must know that at 100-125 feet a gradual cyclic flare should be initiated and that

at 25 feet the landing attitude should be assumed. At approximately 25 feet the collective should be added to recover at 10 feet. A simulator provides an excellent environment where prompts or cues could be used to initiate the above responses at the proper time. Fading could take place after the student had developed a certain proficiency level in performing the autorotation maneuver.

(2) Reinforcement (positive or negative) and Knowledge of Results: Probably the most institutionalized principle of learning and one that most learning theorists think of first is reinforcement, or the introduction of knowledge of results (KOR), during training sessions. The consequences of behavior are stressed by this principle, in particular, positive reinforcement. Positive reinforcement is a stimulus which if it follows an action, or a response, will strengthen and increase the likelihood that the behavior will reoccur, whereas, negative reinforcement is the application of an undesirable stimulus to a behavior in order to eliminate or suppress that behavior [Deese, 1967]. Reinforcement principles are well entrenched in flight training and may consist of grades on exams or flight checks, verbal feedback from the instructor and ultimately, in the Navy, a score on a fitness report.

Flight training abounds in motor skill learning situations and it is in this type of skill acquisition (flying an aircraft) where studies have tended to show that telling the

student whether he is tracking on target or off target (comparable to saying right or wrong) have a fairly immediate effect on the level of performance [Gagne', 1971]. Baily (1978) maintains that learning of any kind will benefit, through use of reinforcement, for the behavior desired.

Flight simulators provide environments where the principles of reinforcement and knowledge of results, if instituted correctly, will enhance the overall training program. Experienced helicopter pilots are able to determine correct maneuver performance with little difficulty from cues received from cockpit instruments and visual reference outside the cockpit. For the novice student pilot this feedback is generally absent and if the necessary cues are supplemented in the early stages, rapid learning may take place [Baily, 1978]. In a simulator, it would be an easy task to provide the student pilot with a signal to indicate to him whether or not his last response or maneuver series was performed correctly or incorrectly. These signals would be in the form of counters or tones which would confirm correct performance. If the maneuver was performed incorrectly a voice generating system within the simulator could indicate to the trainee what corrective actions were necessary.

Modern day simulators incorporate a freeze function which allows the instructor pilot to stop the maneuver for a short period when the student pilot is erring in some flight task. This in essence will produce negative reinforcement. Baily (1978) has indicated that it is not generally recommended

to use a punisher in an educational setting because of the anxiety, fears and aversiveness created in the student. On the other hand, Baily stipulates, that flying inherently has natural punishers for which student pilots should be made keenly aware of and it is through the use of a freeze function that this might be done.

(3) <u>Shaping</u>: A learning principle which keeps the student motivated and involved in the flying task by continually increasing the criterion for good performance, is known as shaping [Kazdin, 1975; Baily, 1978]. As progress is achieved in a flying task the criterion should be raised, under the shaping principle, so only improving performance should be rewarded. This approach indicated by Baily (1978) would aid the student pilot in reaching the final criterion more quickly. Bryan and Regan (1972) have supported this principle in that the loading of the novice pilot, in the beginning stages of learning a task, should be minimal and as training progresses the loading should be increased.

Those in the Navy who transitioned from the fixed winged aircraft to the helicopter, remember the first futile attempt at hovering. Here, it was necessary for the instructor pilot to allow the student to manipulate one control at a time (Cyclic, Collective, Rudder). As performance improved two controls were manipulated concurrently by the student, and finally as training progressed, the student had to manipulate all three controls. In a simulator, when predescribed criterian levels of the hovering task were being met, the student could

be required to cope with increasingly more difficult environmental conditions (turbulence, crosswinds, visibility, etc.), as well as various emergency conditions. Baily (1978) has suggested that the utilization of a flight simulator, in which the level of task difficulty could be gradually increased, would probably greatly reduce the time required to master many tasks.

(4) Backward Chaining: One instructional feature which cannot be performed in the operational aircraft is the principle of backward chaining. Many flying tasks consist of a sequence of activities which always occur in a fixed order. The principle of backward chaining stipulates that the terminal activity as opposed to the initial one is mastered first [Hughes, 1978a, 1978b; Baily et al., 1978; Bryan, et al., 1972]. This approach allows the principle of reinforcement to be applied to the task as it is performed. In the traditional approach, using the aircraft, where the initial activity is learned first, as in a landing pattern, the final stages of touch down and roll-out only receive the reinforcement. This approach will usually deprive the early members of the chain, in this case the landing pattern, of adequate reinforcement, hence their slow acquisition may well retard the development of the rest of the chain.

Flight simulators provide an exceptional environment where the principle of backward chaining can be applied. In a landing pattern task, the simulator can be initialized and

reinitialized on a short final. The student would continue this maneuver until an acceptable level of performance was attained. Upon reaching criterion, the simulator would lead the student back through the sequence of the chain (final, baseleg, downwind, overhead, and break) in a backward chaining structure, until mastery of this complete maneuver was accomplished.

B. CONCEPTUAL TRAINING MODEL

Hughes (1978a and 1978b) has essentially pioneered a conceptual flight training model where a distinction is made between enabling and instructional features and how they may be applied to advanced training features of present and future generation flight simulator training systems. A description of these advanced training features, found almost exclusively in Isley and Miller (1976), is reproduced in Appendix A for those who are not familiar with this aspect of flight simulation.

Enabling features consist of environmental and aircraft conditions that are physical in nature which are required to support training, but are not instructionally manipulative. Environmental conditions are those elements either natural or man-made which are in the simulated environment of the operational aircraft. They consist of motion cues, visual scenes , visibility/ceiling, day/night, etc. Aircraft conditions are features which are related directly to the physical operating conditions of the aircraft and consist of factors such as fuel supply, weight and balance data, and operational

conditions of subsystems, etc. These enabling features essentially create the condition under which training may occur.

Instructional features are broken down by Hughes into passive features (features having no direct contact with the student) and active features (features having direct contact with the student), which manipulate enabling features in the training environment to foster desired pilot performance.

Hughes purpose in establishing this training model was to provide direction to research and development in the area of advanced training, which he contends is presently poorly defined. Research has indicated that training in a majority of present day training systems is simply an accumulation of experience, rather than empirically derived principles of learning.

C. TRANSFER OF TRAINING

1. Concept

Transfer of training is generally defined as a phenomenon where performance on some subsequent task is influenced to some degree by either the experience or performance on some previous task. Transfer of training may take on three different forms as indicated by Ellis (1973):

1. Positive transfer exists where there is a measurable increase of performance from one task to another task.

2. Negative transfer exists where performance is degraded from one task to another task.

3. Zero transfer may occur either as a result of no effects on performance from one task to another or a nullifying of positive and negative effects.

Learning curves in Fig. 2 gives a pictorial representation of these three transfer effects.

Various theories of transfer have been set forth. The most influential of the early theories was that of E. L. Thorndike. His theory of identical elements grew out of experiments which gave subjects practice estimating the areas of various geometrical figures such as triangles and rectangles. Essentially transfer would occur, from one situation to another, to the extent that there were identical or similar elements in the two situations. Other investigators were inclined to accept another theory which addressed transfer through "general principles" which were common to both the original and final task. A more general conceptual framework in which the nature of transfer does not depend on either the theories of identical elements or general principles is one concerned with the basic elements of stimulus-response theory [Deese and Hulse, 1967].

The stimulus-response theory of transfer of training is important because it is easy to generalize. Deese and Hulse (1967) have indicated that the relationship between two tasks, in stimulus-response theory, can generally be described

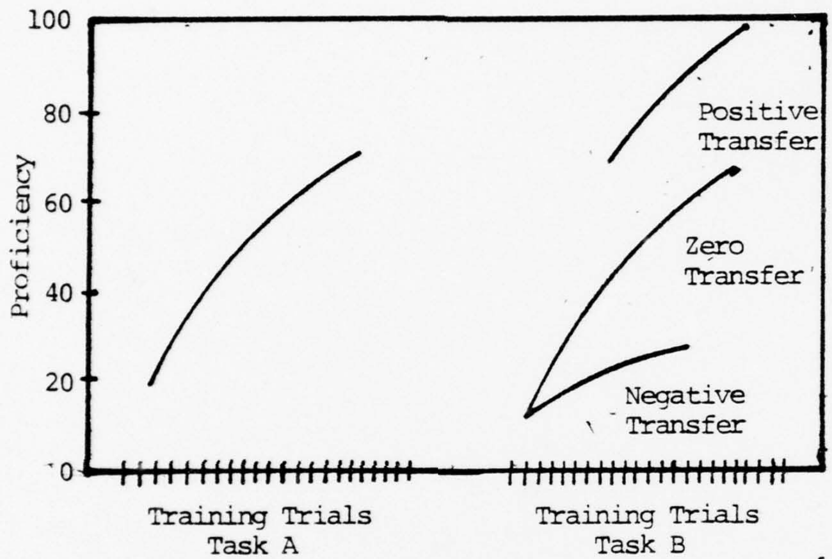

Figure 2 - Negative, Positive, and Zero Transfer
Source: Bryan and Regan (1972)

satisfactorally by indicating how the stimulus in the two tasks resembles one another, and by describing how the responses are related.

There are two approaches to the theory of stimulus-response and transfer given by Deese and Hulse (1967). First, stimulus generalization, a special case of transfer, is a principle where there is a variation in the stimuli between tasks while the response in the tasks are held constant. In testing stimulus generalization, it is necessary to test the strength of some response to stimuli other than the training stimulus. One could conclude that the greater the similarity between the test and training stimulus, the more appropriate the response elicited by the test stimuli. This would imply tht amount of positive transfer would increase or decline (see Fig. 3) as stimuli are changed in a second task, from that which was given in the original task. The second approach to the stimulus-response theory is to change the responses from one task to the next while holding the stimuli constant. This principle emphasized that a second task containing the same stimuli but requiring totally unrelated responses would probably produce negative transfer. It may have been easier to learn the second task if the previous task had not been learned at all [Deese and Hulse, 1967].

Osgood (1949 and 1953) introduced the transfer surface, Fig. 4, which describes the effects various combinations

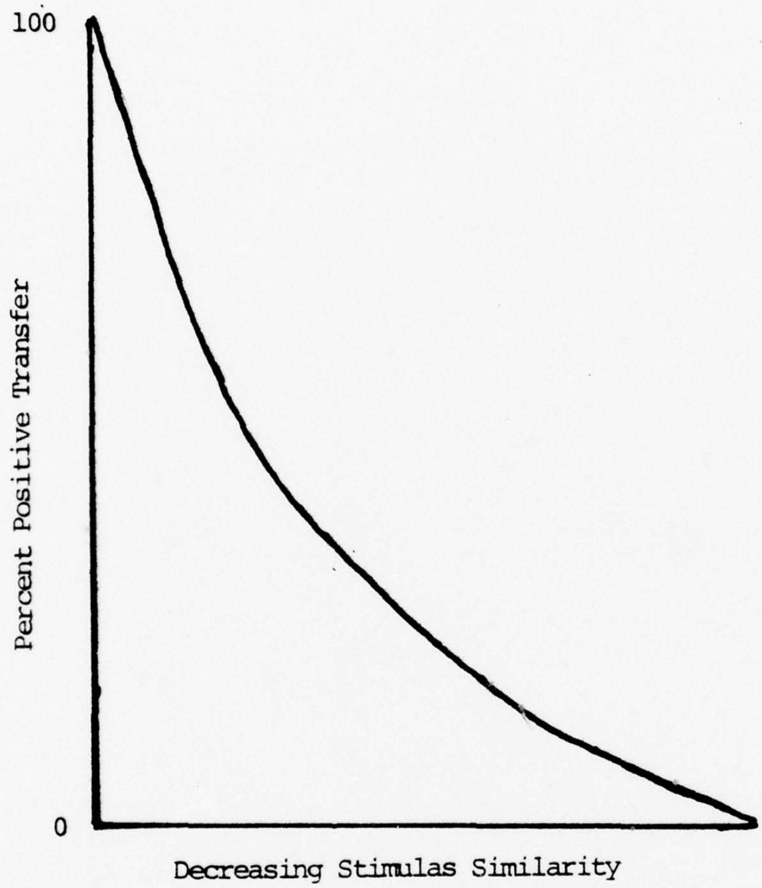

Figure 3 - Constant Response and Varying Stimuli
Source: Deese and Hulse (1967)

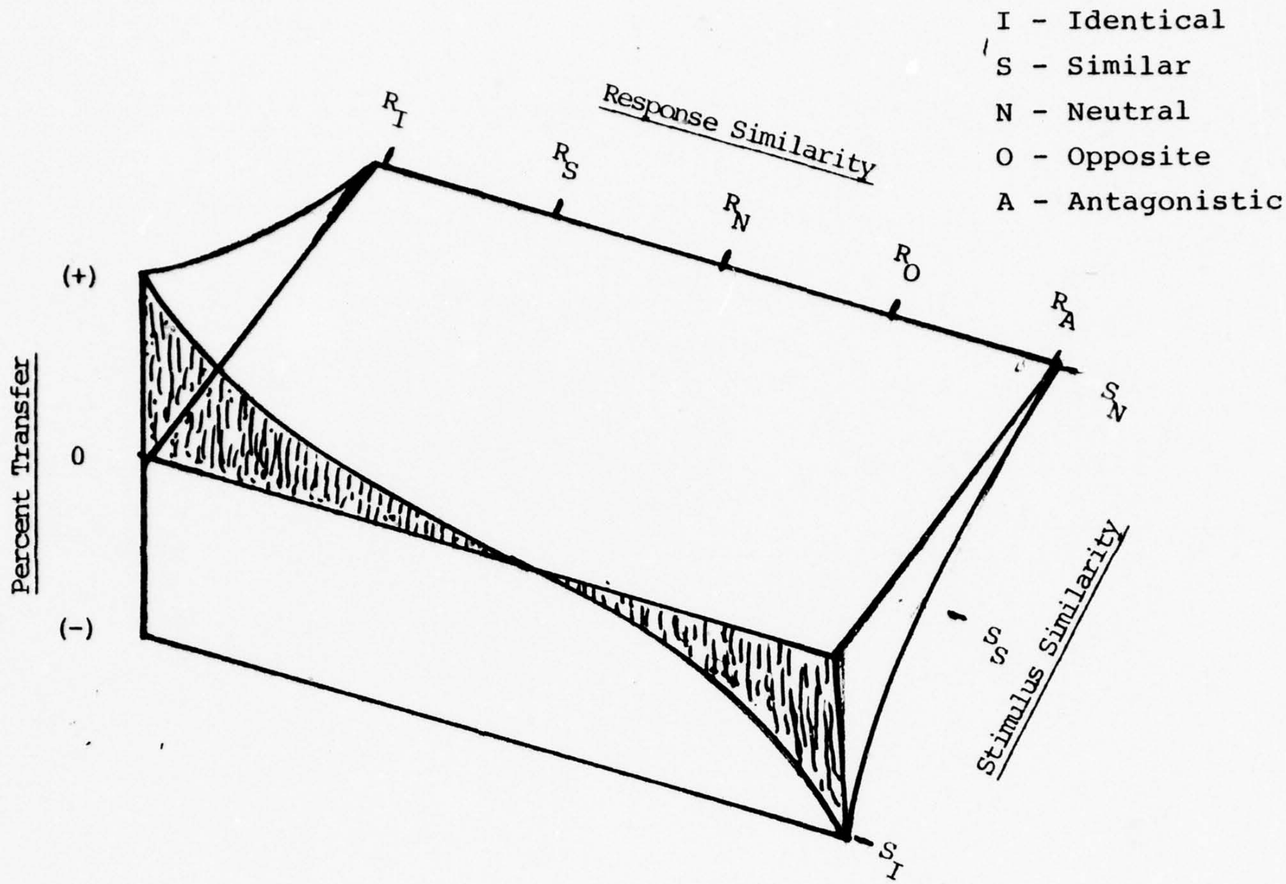

Figure 4 - Hypothetical S-R Transfer Surface
Source: Osgood (1947,1953)

of stimulus-response patterns will have on transfer. The surface is three dimensional in nature with one dimension describing the direction and amount of transfer, another indicates stimulus similarity, while the third describes response similarities. The greatest negative transfer is that part of the surface in the lower right hand corner. Here the stimuli are identical but the responses are completely unrelated. Maximum positive transfer is found where both stimulus and response are identical for the two tasks, as seen in the upper left corner of the surface. Where similarity between stimuli for the task is minimal, as shown on the opposite side of the diagram, transfer, either positive or negative, is very weak. When there is no relation between stimuli and response in the two tasks, no transfer should occur at all.

There is some controversy in the literature concerning the nature of transfer, and how it relates to fidelity of flight simulation. Adams (1972) has indicated that there has not been an upper bound placed on the degree of fidelity which goes into the hardware of the simulator. He, along with others, Muchler et al., (1972), Prophet (1966), and Micheli (1972), have indicated that training effectiveness is a function of trainer usage and training program design, rather than the fidelity of the trainer. More recent studies indicate that fidelity can effect transfer of training, but only when considered in the over all training program [Provenmire and Roscoe, 1973; Caro and Prophet, 1973; Valverde, 1973;

Williges et al., 1973; Hopkins, 1975; Caro, 1976, 1977; Finnegen, 1977].

2. <u>Measurement of Transfer of Training</u>

Over the years a number of researchers have developed indices with which flight simulator effectiveness can be quantified. Through their independent efforts a lack of standardization in terminology and usage has evolved. The result is that a common measure is lacking with which to compare transfer from various studies with different simulator training programs, skill levels, etc., Diehl and Ryan (1977), and Orlanski and String (1977), have suggested three formulas in current use which might be used systematically to estimate the effectiveness of various factors which might influence flight training.

<u>Percent Flight Syllabus Reduction (percent savings)</u> is a measure of the simulator and/or other training innovations, e.g., the ability of a revised syllabus to reduce flight time in a training program. The larger a positive number is, the more effective the simulator and/or training program are. Negative values can occur if more flight hours are needed to complete the syllabus after the introduction of the flight simulator.

$$\text{Percent Savings} = \frac{Y_C - Y_X}{Y_C} \times 100$$

Y_C = original flight hours, or time, trials or errors required by a control group to reach criterion

Y_X = new flight hours or corresponding measure (as in Y_C) for an experimental group which receives practice on another task.

Flight Substitution Ratio (FSR): FSR indicates the rate at which flight hours are replaced by simulator hours, and therefore, is an index of efficiency that expresses the ratio of the increase in simulator hours to a decrease in flight hours needed to complete the flight training syllabus. Smaller values of a positive FSR are indicative of more effective simulator to flight hour substitution. Negative FSR occur either where increased simulator and flight hours occur, or where there is a reduction in both simulator and flight hours.

$$FSR = \frac{X_E - X_C}{Y_E - Y_C}$$

X_E = new simulator or time required in simulator by experimental group.

X_C = original simulator hours or simulator time required by control group

Y_E = new flight hours or aircraft time required by experimental group

Y_C = original flight hours or aircraft time required by control group.

Transfer Effectiveness Ratio (TER): Developed by Roscoe (1971) has been widely used in transfer of training

experiments. This ratio compares the flight hours saved to the time spent in the simulator and is essentially the reciprocal of FSR.

$$\text{TER} = \frac{Y_C - Y_X}{X}$$

Y_C = original flight hours, or time trials, or errors of control group to reach criterion

Y_X = corresponding measure for experimental as for the control group

X = new simulator hours or simulator hours in experimental group or new program.

If there were simulator hours in the old training program, TER should be modified as follows:

$$\text{TER} = \frac{\text{Original Flight Hours} - \text{New Flight Hours}}{\text{New Simulator Hours} - \text{Original Simulator Hours}}$$

<u>Incremental Transfer Effectiveness Ratio (ITER)</u>: Developed by Roscoe (1971, 1972), describes diminishing returns to training effectiveness by successive increments of training in a flight simulator.

$$\text{ITER} = \frac{(Y_{X-\Delta X}) - Y_X}{\Delta X}$$

$Y_{X-\Delta X}$ = amount of time, trials or errors required by experimental group to reach criterion after having received $X-\Delta X$ training units on a prior task.

Y_X = corresponding measure for an experimental group having received X training units on a prior Task (same as Y_X above)

ΔX = incremental units in time, trials or errors during prior or interpolated practice on another task.

A word of caution is in order here regarding accepting the above transfer of training formulas at face value. While these indices provide a means of comparing different training program's simulator effectiveness, there is little contribution given to the understanding of the training value of the simulators themselves [Caro, 1976a, 1976b]. Stabilized performance is an assumption inherent in a measure of transfer of training. In order to measure the effectiveness of a device correctly, the task to be learned must be well defined and there must be well established bounds placed on the performance indices. Chalk (1976) contends that when the performance indices are not defined the value of transfer of training is somewhat suspect. He goes on to state that when a task becomes complex there appears to be little agreement on the best way to combine specific activities, therefore it may be either impossible or impractical to define a meaningful measurement of performance. These conditions are most relevant in helicopter flight training as well as other disciplines. The heart of the problem is that performance assessment criteria that are applicable to the real world, have not yet been identified [Chiles, 1971].

One should be able to accept these arguments if adequate consideration is given to the complexity of dependent and independent variables which enter the learning environment. There are a number of physical factors such as sex, age, strength, psychomotor skills, and visual acuity. Intellectual factors which may influence the training situation are intelligence, prior experience with the device, and motivation. Physiological considerations are concerned with the general condition of the individual in training. Factors to consider here are fatique, or general wellbeing of the individual. Personality traits such as timidity, or aggressiveness, self confidence, or the lack of self confidence also influence learning. Instructional techniques, spacing of trials and amount and spacing of reinforcement, as well as the instructor himself can have profound effects on the training environment and hence are able to influence the performance indices given to measure the effectiveness of the training system [Chapanis, 1967].

V. FACTORS WHICH INFLUENCE TRAINING EFFECTIVENESS

A. PERSONNEL

The effectiveness of any training program can be affected, either positively or negatively, by the personnel involved. Simulator training systems incorporate the interaction of two groups, instructors and trainees, which may influence effectiveness differently depending on either background factors (prior experience, qualifications, etc.), or physiological or psychological factors (stress, motivation, fatique, attitudes, and aptitudes, etc.). The complexity of the interaction can become quite significant and as stated by Caro (1976), may produce inconsistent results in transfer studies. Since these human inputs can be quite diverse, this report will focus on the more obvious personnel factors suggested by findings in the literature.

1. Instructors

Probably the most important ingredient in any training program is the instructor. His biased attitudes, abilities, and motivations may have a profound effect upon the learning situation [Valverde, 1973]. Past studies have shown that the trainee's attitude is simply a reflection of the instructors attitude, therefore, if the instructor pilot (IP) exhibits disdain or a lack of confidence in the simulator, these beliefs may be acquired by the student pilot. This would indicate that the selection and training of the

IP is an important factor in the implementation of any training program.

What particular attributes and experience levels a simulator instructor pilot should have is not well founded in the literature. Caro (1977) has indicated that even personnel with no flight experience may, through proper training, become effective simulator instructors. An alternate view, is that both proficiency and experience level may have a significant impact upon simulator training effectiveness. An instructor's credibility may be lowered if he himself cannot perform various flying tasks [Caro, 1977]. This would indicate that if the student is to have confidence in the instruction given, the IP should be well qualified in both the aircraft and the simulator. This conclusion is supported by a survey conducted by Chalk (1976).

Instructors, in order to be effective should be well prepared for their job. This preparation could provide: direction to the IP in implementing the various capabilities of the device, and how different media and other training aids should interact with the simulator in the training program. Through this preparation, any reluctance the instructor might have in using the simulator may be removed.

Caro (1977), in a study done on Air Force simulator effectiveness, found that even though instructor behaviors are crucial to simulator training, no attempts were being made to insure adequate training or standardization among

simulator instructors. The principal deficiency in the instructor training is that little training is given in specialized knowledge and techniques which allows the IP to capitalize on the unique training features of the flight simulator. In a study done by Charles (1978) for the Navy, the theme is quite similar. IPs are not trained in simulator operations or methods of instruction. In short, simulator instructors are untrained for the job in that they are not provided essential information for the task (e.g., syllabi, scripts, and scenarios).

Obviously, if any training program is to be effective, the instructors must be well trained. Instructors must be shown that simulators have unique training value and are not just designed to reduce flight time. Through a well-structured training program, positive instructor opinions concerning simulator training could be fostered in addition to standardizing program content.

2. Trainee

The attitudes, expectations, proficiency and experience level of the trainee may influence simulator training differently. The attitudes and expectations of the trainee can play a major role in any training situation [Valverde, 1973]. The literature has shown that pilots with years of flying experience tend to place less credence in the ability of the simulator to provide an effective training medium. These attitudes are due possibly to the pilot's previous

experience with out-dated trainers that provided poor fidelity of simulation and were generally inadeuately maintained. Pilots who have started flying in the recent past apparently have not developed these biases against simulator training.

Orlansky and String (1977) have shown that only 9 percent of flying costs go to training undergraduate pilots, while the remainder is distributed between transition and continuation training. This subset contains pilots with more years flying experience, who possibly maintain biased opinions about flight simulators. This should indicate to any training manager involved in transition or continuation flight training, a need to incorporate a flight simulator familiarization program. This program would indoctrinate transitioning pilots as to the potential advantages and benefits of the simulator as a tool in acquiring the skills necessary to fly in the aircraft. Hopefully, this would foster good attitudes and expectations towards the use of flight simulators.

The skill levels or previous flight experience of the trainee might also influence simulator training effectiveness. Caro (1976a, 1977) has reviewed studies which indicated that managers of current training systems acknowledge that simulators provide appropriate training for trainees with thousands of flight hours, e.g., airline pilots, but contend that simulators cannot be relied upon extensively to train military pilots with 1000 or fewer hours. However,

experimental evidence has not indicated that simulator training can be designed and conducted for one level of experience and not for another. In fact, when isolated from other factors, there is no supporting evidence to show that there is a correlation between level of trainee experience and simulator training effectiveness. Two studies by Micheli (1972), and Brictson and Burger (1976) have found that simulator training is effective for both low and high-time pilot trainees. The proficiency level of a particular pilot at the time of simulator training may possibly influence the potential training effectiveness of the device. It has been suggested that a continuous simulator training program will be less effective for pilots conducting daily operational missions as opposed to those assigned to staff positions having limited flying opportunities. A given simulator training program can be either effective for low proficiency pilots, or ineffective for proficient pilots because of the performance proficiencies and deficiencies associated with each [Caro, 1977].

B. TRAINING PROGRAM CONTENT

The key to achieving the most benefit in simulator training efficiency is through a well designed training program. Program design which is inseparable from effective training has received attention only recently. Caro and Prophet (1973) have established a number of features which are essential for effective and efficient training: better simulators, clearly defined content, and well-qualified

instructors. The description of the above features are a little too general in nature, and more specific definitions of what constitutes a well-qualified instructor or a well-designed program, are necessary to achieve the goal of efficient development of trainee skills.

In the utilization of the CH-47 and UH-1 helicopters, Army helicopter aviation in cooperation with HumRRO Aviation Division, have attempted to develop simulator training programs which implement the techniques of training and learning theory. This work has covered a number of activities associated with pilot training including:

1. Definition of the training requirement.
2. Design of the aircraft simulator.
3. Development of the simulator training program.
4. Evaluation of transfer of training.

Caro (1973), and Caro and Prophet (1973), in their work with HumRRO, have attempted to implement innovative training techniques made through applied training research from various settings. They have avoided structuring training on the basis of the characteristics and practices of traditional in-flight training, and have focused their attention on maximizing simulator training through utilization of unique simulator capabilities which lend themselves to conditions that foster human learning.

Some of the training and management features derived by Caro (1973), Caro and Prophet (1973) and Weyer and Fuller (1976) are as follows:

1. Functional Context Training. This principle organizes training around sets of meaningful, purposeful mission modules.
2. Individualization of Training. This technique is essentially adaptive training, where the material and/or task presented to the trainee depends on his current state of knowledge and skill level [Bryan and Regan, 1972]. When used in flight simulation, Hughes (1978) maintains that in adaptive training techniques the difficulty of a task is adapted to coincide with the skill level of the trainee. As the trainee increases in skill level the task is made more difficult until it either exceeds or parallels the requirements of the task in the operational setting.
3. Sequencing of Instruction. This principle dictates that prerequisite knowledge and skills will be mastered before the trainee is allowed to progress.
4. Minimizing Over-Training. Here criterion performance levels are established and steps are taken to insure that after the trainee has reached criterion no further training is given. Incremental transfer established by Roscoe (1971, 1972) may be applied to this principle where additional training in a simulator or a particular task promotes a diminishing return to transfer. Therefore, if the trainee continues training after reaching the required skill level, inefficiency will enter the system.

5. Efficient Utilization of Personnel and Equipment. Instructors who are qualified for the task, and are given either the proper media or correct training device for the particular task to be trained, will be able to efficiently utilize training time while administering the training in a standardized manner. One productive approach, shown by researchers, is to assign the job of simulator and aircraft training to the same instructor on a one-to-one basis with the student [Weyer and Fuller, 1976]. This will allow the instructor to closely monitor the progress of the student, schedule remedial training if necessary, and evaluate the effects of simulator capabilities on training and on transfer to the aircraft.

6. Team Training. The concepts in either a peer or crew training environment allows one trainee to observe and be involved in the training of another. Also by using team training, the instructor is moved to another seat position which allows the training of pilots and co-pilots tasks simultaneously, thus increasing simulator seat availability. One attribute of team training examined by Woodruff and Hagin (1973) in a study on T-37 undergraduate pilot training, showed that students who performed while being watched by their peers tended to exhibit superior performance.

7. Minimizing Equipment Costs. The idea here is to train, where practical, in low fidelity devices (part-task or

procedural trainers) to maximize cost effectiveness. Bryan and Regan (1972) contend that skills required in the early stages of learning a specific task are often quite different from those required later. Thus, when a trainee is first learning a sequential procedure in a new system, there is no need to overload him with cues that a full mission simulator would provide. As training progresses though, it becomes necessary to integrate the dynamics of the real environment into the training session. Here the capabilities of the full mission simulator may be used more effectively.

8. Objective Performance Measurements. In order to relate the performance of the trainee to the simulator or the aircraft he controls, the training criterion should be stated in objective, measurable terms. With this objective data it becomes possible to transcend the biases of personnel or other factors in evaluating situations, and the data obtained may have more credibility as a dependable measure of performance. This technique should be applied to daily training sorties as well as checkrides.

9. Feedback. Simulators today allow precise and immediate feedback to the trainee. Bryan and Regan (1972) have shown that systems which supply feedback in a training situation will tend to expedite learning. One type of feedback is knowledge of results, which was discussed previously in the section on training. This principle

urges that the trainee be informed regarding the correctness of his action as soon as possible.

These program structural techniques, when employed correctly, can form the basis of a sound training program. These techniques are not limited to their application in training devices per se, but are quite useable in any training environment. Their addition will be beneficial to the efficiency of any simulator training program.

C. SIMULATOR DESIGN FEATURES

1. Fidelity

The definition of fidelity can be a very elusive one and is generally a function of the speaker and his background. A physical interpretation describes a one-to-one relationship between the simulator and its counterpart aircraft. Degree of physical fidelity can be defined to mean accuracy with which features of the simulator approach those of the aircraft. Orlansky and String (1977) contend that fidelity is not a general characteristic of a simulator, but a way in which the many details of the simulator may be described, e.g., the control and instrument display layout of the cockpit, the nature of the aerodynamic flight equations, the data processing which determines the movements of the controls, and the visual and platform motion characteristics of the simulator.

The degree and type of fidelity needed in a simulator is obviously a function of its intended use, e.g., contact

flying needs a visual system whereas instrument flying, for the most part, can be trained without it. The amount of fidelity for various flying tasks has not yet been specified. As yet, the literature does not contain evidence to show that well controlled experiments, coupled with appropriate data analysis, have been conducted to specify the amount and type of fidelity, e.g., 3 or 6 degrees of freedom in the motion base, or type of motion, size of the field of view, and the need for color rather than black and white in the visual scene [Caro, 1976; Orlansky and String, 1977]. The concept presented in the often discussed cost, fidelity and transfer of training curves is that cost is exponentially associated with fidelity. This would indicate a need exists to specify the amount and type of fidelity needed in the simulator to transfer the necessary skills to the operational environment. Obviously a trade-off analysis is needed between fidelity and costs in light of current reduction in fiscal expenditures.

Woods (1977) has placed the concept of fidelity of simulation into two dimensions with hopes of attacking costs considerations of fidelity more productively. These two dimensions are:

1. Objective fidelity where emphasis is on physical events.
2. Subjective fidelity where fidelity is person-centered and concerns only man's perception of simulated events.

The first dimension is quite costly and may not provide the quality of simulation necessary and sufficient for effective training. The second dimension of fidelity is an operator requirement which can assure proper training through quality simulation. This subjective form will be less costly when efforts are made to provide the trainee with only that information needed to learn the training tasks at hand.

2. Motion

The design of motion fidelity into a simulator system can vary from two degrees of freedom system (pitch and roll), to the sophisticated synergistic six-degrees of freedom system (forward, lateral, heave, pitch, roll and yaw). The degree to which the amount and degree of motion fidelity contributes to transfer of training has been highly suspect in many recent studies. In most cases students trained without motion performed comparably to students trained with motion. This would indicate that the presence of motion does not appear to make a significant observable contribution to flight performance [Gray, 1977; Waag, 1978; Cyrus, 1978; Martin, 1978; Orlansky and String, 1977; Caro, 1977; Deihl and Ryan, 1977]. The consensus of these studies is that platofrm motion adds very little to the transfer of flight tasks. This is especially true when the simulator used incorporates a full field-of-view visual system [Howe, 1977].

Gundry (1976) discusses the influences of motion upon pilot performance and makes a distinction between two kinds of motion (maneuver and disturbance), and suggests

they may affect performance and transfer differently. Maneuver motion results from changes initiated by the pilot in the motion system of the simulator in order to change heading, altitude and attitude. Maneuver motion contributes little to the training situation in that it does not fulfill any alerting function. Disturbance motion, on the other hand, is outside pilot control and results from turbulence or failure of airframe components which cause an unexpected change in motion of the aircraft. One component failure in the H-46 helicopter which will provide disturbance motion cueing is the Stability Augmentation System. This system is required to stabilize inherently instable aerodynamics of the H-46 about the pitch, roll, and yaw axes. Disturbance motion can aid training in a simulated environment in that it provides for more rapid and relevant alerting cues about forces acting upon the aircraft than can be obtained from other cue sources.

In many of the studies cited above, emphasis was upon simulation of maneuver rather than disturbance motion. When sufficient feedback is available from other sources (visual and instrument indications) a large impact upon simulator training effectiveness cannot be expected to come from maneuver motion. It would appear that the case for motion in flight simulation should be reexamined. The evidence given by Gundry would indicate that disturbance motion may have a large effect upon transfer of pilot performance from the

simulator to the aircraft, and should not be overlooked by individuals making decisions concerning the importance of platform motion in simulator training systems.

3. Visual

Tasks which are not duplicated or even approximated in the simulator will not be learned for subsequent transfer to the aircraft. Therefore, a simulator in which more flying tasks are characterized will provide the potential to obtain greater training effectiveness in the training program [Caro, 1977].

There has been a number of simulator training studies involving visual displays in which transfer of visual flight skills has been demonstrated. Waag (1978), in a study summarizing these studies, points out that visual simulation has successfully demonstrated transfer of training in fighters, transport fixed winged aircraft, as well as for rotary wing aircraft. The skill level of the pilots did not effect transfer, and in all cases positive transfer of training was observed. Even in a very crude visual system, which consisted of a line drawing of a runway on a blackboard tilted by an instructor to make the runway change perspective, positive transfer was observed [Waag, 1978; Caro, 1977].

There are three basic visual systems in use today; the TV Model board, computer-generated imagery (CGI), and film. Only the model board and the CGI systems are used in present state-of-the-art simulators and therefore will be the only ones discussed in this paper.

The Advanced Simulator for Pilot Training (ASPT) essentially pioneered the full-field-of-view (plus or minus 150 degrees horizontally, by plus 110 and minus 40 degrees vertically) computer generated image system. The visual system uses an infinite optic display with the exit pupil located at the student's eye position. The scene is projected through seven 36 inch cathode ray tubes [Waag, 1978]. The major advantage of a digital image system is the tremendous amount of flexibility in providing any kind of visual information required [Stark, 1977]. Many present designers and users feel that through the technological advancements made in the CGI visual system, the future needs of visual fidelity will be met. The idea of having a visual system which reproduces scenes such as take-off, and air refueling, formation flight, air to air combat, air to ground attack along with enemy defenses and landing, may represent the ultimate in a system. The possibility of stored programs of world wide target areas is presently quite conceivable.

Some problems are presently plaquing CGI systems. First, there is an upper limit on the number of edges (a straight line segment betwen two vertices), that the system can generate to depict realistic scenes. Efforts to alleviate this problem are being undertaken by Rife (1978) who is using a Level of Detail Processing technique to eliminate objects or faces too small to be perceived at various distances, thus reducing the possibility of overloading the edge capacity

of the computer. The second problem, one not related to technological limitations, is the considerable effort needed to produce the data base describing the areas and tasks to be simulated [Hoog and Stengel, 1977]. Presently, there also exists a lack of standardization of data bases which precludes the utilization of environments generated at one facility, from being directly applied at another [Monroe, 1977].

A TV Model board is a scaled down physical representation of the real world. An optical probe and television camera mounted on a gantry moves over the environmental model as if it were the aircraft and transmits this scene to the cockpit of the simulator. TV model boards provide for color and more realism in the appearance of the simulated visual scene, but lack flexibility and variety in training certain contact flying tasks, and for these reasons are being replaced by CGI systems.

4. Conclusions

Senator Barry M. Goldwater had some pertinent questions that should be answered by designers and users before trying to reach real world visual duplication. These questions are as follows:

1. How close to the real world must these artificial scenes be in order to achieve the required training benefit?
2. How much should be paid for that capability?
3. When will we know when we have answers to the first two questions?

VI. H-46 (OFT) DEVICE 2-F117B

A. GENERAL DESCRIPTION

The H-46 operational flight trainer (OFT) provides the means to develop pilot proficiency; in the operation of controls, interpretation of instruments, operation of navigation and communication systems, and training in coping with a variety of emergency situations. The physical configuration of the simulator as well as the location of subsystems can be seen in Fig. 5.

The OFT incorporates a fully simulated cockpit which includes real-time simulation of all flight controls, gauges, indicators, and circuit breakers. Engine operation and control within the cockpit provides for training in single or multiple engine failure analysis. Full simulation of navigation/communication systems is provided for and include: UHF, UHF/DF, FM, KY-28, HF, TACAN, LF/ADF and IFF. Weather environmental conditions include rough air, gusts, and hail. Simulated aircraft sounds include rotor brake, igniter noise, compressor stall, APU squeal, runway rumble, as well as engine sounds. Total simulation of vibration which include rotors and transmissions are also obtained.

Flight training can be enhanced through the OFTs high fidelity simulation of aircraft performance and flying qualities. Flight cues, provided by the six-degree of freedom motion system simulate in-flight motion characteristics, ground

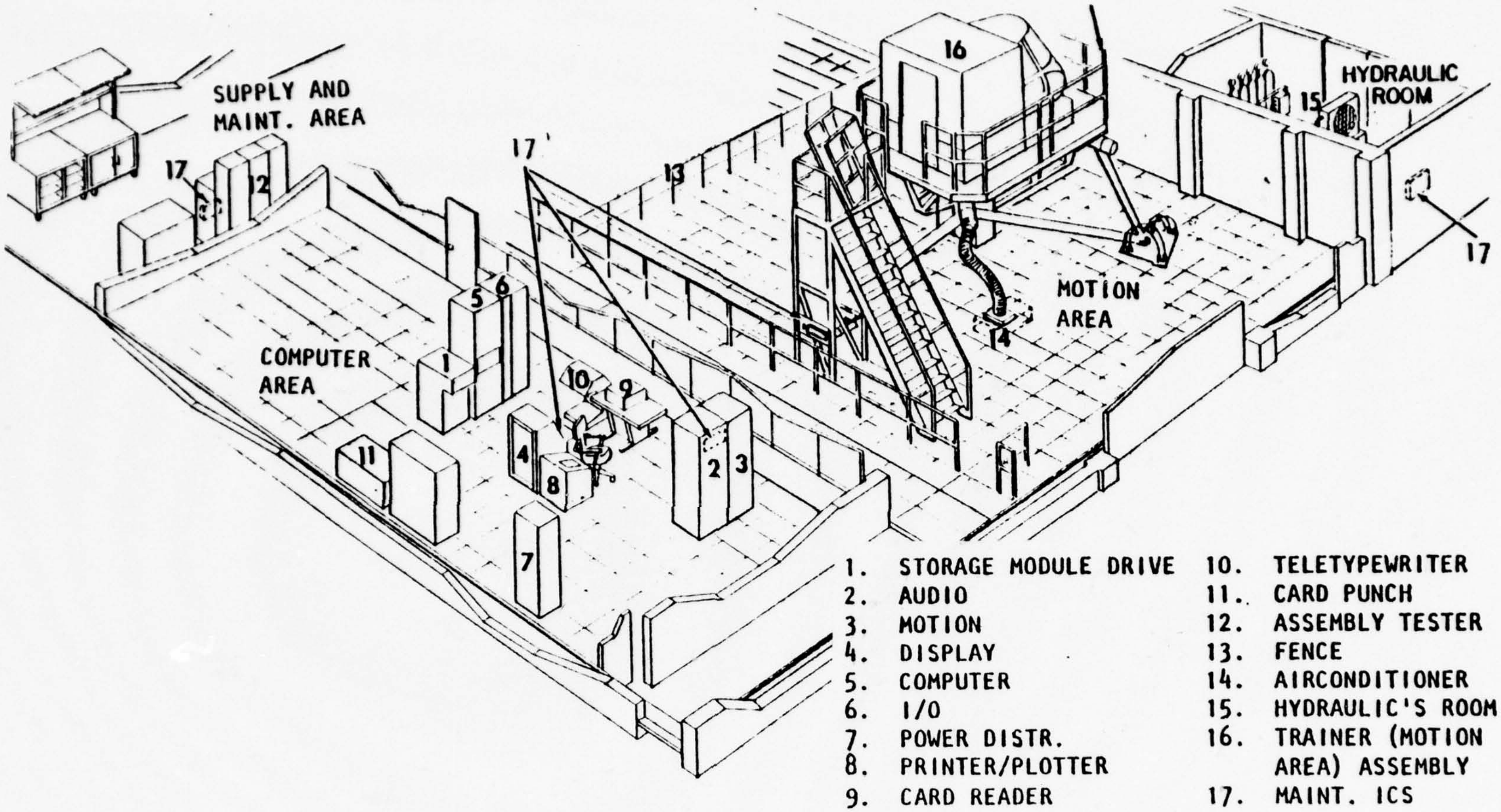

Figure 5 - Physical Configuration of the H-46 OFT

handling, shipboard handling, buffet and vibration. The on-board instructor's console provides for total control of flight problems and monitoring of trainee performance. The design features of the instructor's console provide for automatic demonstration of flight profiles, instant playback of all cockpit controls and indicators, trainee exercises and checkrides, as well as controls to position the simulator at locations within the problem world for rapid problem initialization.

The computer consists of a Harris Slash 4 computer, which possess 82k words of core memory and over 40 megabytes of disc storage. A disc operated system capable of handling real time and batch operation is provided along with automatic hardcopy and instructor selected hardcopy printouts of trainee performance. A full complement of diagnostic and support programs (e.g., trainee performance evaluation, CRT display compiler, and built in test capability), are provided for.

The H-46 flight simulator will be equipped, at a future date, with a CGI full day-light visual system. The six-window system will provide training in contact type tasks as follows:

1. Confined area landings and takeoffs.
2. Shipboard landing and takeoff operations.
3. IFR and VFR field operations in day, dusk or night conditions.
4. Sling load operations.
5. Formation flying.

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The trainer includes a unique training feature, a Remote Trainer Control Panel (RTCP) at the center console. The RTCP allows the instructor to fly as a pilot or copilot, and exercise limited control of the trainer. In addition, the RTCP permits self training, which includes playback of the most recent 5 minutes of the exercise in increments of 6 seconds.

The trainer has another playback mode which provides playback of trainee performance with accompanying voice commentary of the most recent 5 minutes in 30 second increments. To accommodate real world changes, the instructor can modify existing pre-programmed initial conditions, or he can generate a new set. The instructor can generate new demosntrations, including the use of appropriate malfunctions. The simulator can simulate 189 emergency malfunctions either individually or up to 10 at one time during a training session.

B. SYSTEM TRAINING FEATURES

The H-46 OFT is a high fidelity device which realistically duplicates the actual helicopter environment. A comprehensive list of system features and characteristics is beyond the scope of this present effort, but can be found in NAVTRADEV P-4313, 1 May 1978, change 2, 9 Feb 1979. It should be kept in mind that this publication is for device 2-F117 and that through minor modifications will accommodate device 2-F117B. Those features which most affect H-46 pilot and copilot training have been extracted from NAVTRADEV P-4313 and are presented below.

The simulator provides for simulated training exercises divided into categories of pretaining diagnostic exercises, training exercises, and post-training exercises. These exercise modes assist the instructor pilot in performing his training mission.

Pretraining Diagnostic Exercise. Ground station communication, activities of other crew members, and the monitoring of student performance is provided in this exercise. During this exercise errors are recorded and at the conclusion of the exercise, a hard copy of errors are available for analysis and critique. The instructor is essentially able to determine the student's proficiency level prior to progressing to the other training programs during this exercise mode.

Training Exercise. The training exercises consist of three modes: free flight mode, demonstration mode, and the exercise mode, which will be described in the following paragraphs:

1. Free Flight Mode. The free flight mode enables the pilot total control of cockpit controls and allows him to have a free hand in simulated flight. The free flight mode is used primarily for the introduction of new flight tasks where no pre-programmed or automated demonstrations exists. In the free flight mode the instructor is given a wide latitude in controlling an exercise of his own design by making modifications in training approaches to suit the needs of a particular pilot. The instructor has the capability to freeze the

simulated flight as desired, as well as the entry and deletion of simulated malfunctions.

2. Demonstration Mode. The demonstration mode enables the instructor to manually demonstrate an aircraft maneuver or a series of maneuvers for the trainee's benefit, or select an automated demonstration maneuver which is automatically flown by the trainer. A pre-recorded audio briefing precedes the desired demonstration for the manual mode and describes the maneuver as it is being flown in the automatic mode. The instructor can freeze the demonstration at any point and then unfreeze to resume the demonstration.

3. Exercise Mode. The exercise mode is very similar to that of the checkride mode. In this mode the instructor can intervene to increase or decrease the difficulty of the exericse, by changing the environmental parameters and/or entering or deleting simulated malfunctions. There are six pre-programmed exercises containing all the conditions for the exercise and include flight, navigation and environmental parameters. The pre-programmed exercise is a pre-established flight plan that must be adhered to by the trainee. In many cases, the pre-programmed exercises in the trainer represent established instrument hops that are flown in the actual aircraft. These programs are defined in terms of specific tasks to be accomplished such as takeoff and climb, holding, altitude, air speed, and navigation facilities to be used.

Appropriate displays are provided to assist the IP in monitoring trainee progress during the course of the exercise. As the exercise proceeds, trainee performance is constantly monitored by the computer and compared with a set of performance tolerances. At the end of the exercise the out-of-tolerance excursions are printed out to be used to critique as well as evaluate pilot performance.

Post-Training Exercise. This exercise is a checkride mode which tests the trainee's skills developed during the course of training. The checkride mode is a hands off exercise where the instructor does not engage in any teaching activities. Upon completion of the automatic briefing at the beginning of the exercise, the trainer automatically goes into a freeze mode. When training begins, the checkride continues uninterrupted unless the simulator crashes or some other emergency arises which necessitates termination. In conjunction with monitoring this exercise, the instructor has the additional responsibility of acting either as a crew member or simulating ground station transmissions. If the trainee makes a communication error, the instructor activates a control which causes an error to be entered. Again, as in the exercise mode, trainee performance is monitered and compared with a set of performance tolerances, which is printed out at the conclusion of the checkride.

The chekcride is an automated flight plan from takeoff to landing, that must be adhered to by the trainee. As in the exercise mode, the checkride exercise is defined in

terms of specific tasks to be accomplished by the trainee. To assist the IP in following the trainee's progress, numerous displays are provided for this purpose.

VII. H-46 (FRS) TRAINING PROGRAM

The present and proposed training programs presented in this paper will be constructed for HC-3, a west coast helicopter Fleet Replacement Squadron, stationed aboard NAS North Island, San Diego, California. East coast helicopter squadrons have essentially the same mission and training requirements as HC-3, therefore, the proposed training program given in this report can be easily generalized.

When device 2-F117B is first received by HC-3, it will not have any external visual scene presentation capability, but will be retrofited at a later date. For this reason, two approaches for a proposed flight training syllabus will be recommended, one in which the OFT will not be able to train in any contact flying tasks, and one in which it will.

A. PRESENT SYLLABUS

Presently, all flight training at HC-3 is conducted in the H-46 helicopter and is tailored to meet the individual needs and requirements of student pilots, as well as the more experienced pilots receiving advanced training in the Functional Check Flight or Instructor Under Training programs. HC-3 instruction (1500.1A) coupled with OPNAVINST 3710.7 series constitute the qualification requirements for Helicopter Aircraft Commander (HAC), Helicopter Second Pilot (H2P), Functional Check Pilot (FCP), and Instructor Under Training (IUT).

Ground school training comes from various sources which includes instrument flight rules training and H-46 systems training. Instrument flight rules is taught in a three day course offered by HS-10, a helo squadron stationed aboard NAS North Island. This course is taken annually in partial fulfillment of requirements for an instrument rating. H-46 systems training comes from a number of sources:

1. One week squadron course
2. One week formal course
3. NATOPS manual
4. PQS (personal qualification standards)

The formal one week systems course is given to either first tour pilots or second tour pilots without previous H-46 experience. Additionally, a one-week in-house systems course is given to all pilots. The NATOPS manual provides the standardization from which the pilot learns flight characteristics, emergency procedures, all weather operations, communication procedures, flight crew coordination and performance data. PQS is supplemental to the NATOPS manual and describes the needed skills to perform various flight tasks. General theory and systems are identified in PQS to insure that prerequisite knowledge is gained to properly perform required flight tasks. PQS is broken down into: a theory, systems and watchstation (task description of complete task) sections. Except for the two one-week systems courses, the ground school portion of this present training program is self-taught,

augmented by discussions with HACs either informally or during briefs associated with syllabus training flights.

The general flight training (required for both HAC and H2P designations) syllabus is shown in Table I., and a modified syllabus (for second tour pilots with previous HAC H-46 qualifications) is presented in Table II.

The Functional Check Flight program is an in-house course which is used to provide further training for HACs in order for them to obtain FCF designations. The course is divided into a ground school and flight training portion. The ground school is a one week course which provides an indepth analysis of aircraft systems. The flight portion of the syllabus is presented in Table III.

HC-3 is both an operational squadron as well as a FRS. It therefore has pilot billets consisting of either shore or sea. Instructor pilots are shore billeted HACs and before being designated IPs must complete the IUT syllabus as shown in Table IV.

1. Costs

For any training program to be totally effective, it must be cost effective. Estimates of flight costs for the CH-46D helicopter were derived directly from averages in the Navy Program Factor Manual, OPNAV-90P-02B, revised 31 August, 1978. Cost per flight hour plus cost per pilot for each syllabus are summarized in Tables V and VI.

FLIGHT/BRIEF	INSTRUCTOR	PREREQUISITES
FAM 1 & 2	H2P	FAM 0
FAM 3	HAC	
FAM 4	INSTRUCTOR/ANI	HC-3 PILOT FAM COURSE
FAM 5-10X	INSTRUCTOR/ANI	COURSE RULES EXAM PRIOR TO FAM 6
INST 1 (DAY VFR B.I.)	INSTRUCTOR/ANI OR INST CHECK PILOT	INST 0 NATOPS open book exam
INST 2 (DAY LOWLEVEL OVERWATER)	HAC	
INST 3 (DAY APPROACHES)	HAC	
INST 4 (CROSS COUNTRY)	HAC	
NITE 1 (PADWORK)	HAC	INST 1 & 2
NITE 2 (NITE INSTS)	HAC	INST 1 & 2
NITE 3 (REVIEW 1 & 2)	HAC	NITE 1 & 2
NAV 1 (DAY VFR, OVERLAND) (MTN, PADS)	HAC	INST 1
NAV 2 (DAY VFR OVERWATER)	HAD	DR COURSE/MK-6
CARGO 1 (LITE LOAD)	INSTRUCTOR/ANI	
CARGO 2 (HEAVY LOAD)	HAC	CARGO 1
CARGO 3 (NITE CARGO)	HAC	NITE 1
SHIP 1 (LANDINGS)	HAC	OP 0 STAGE BRIEF
SHIP 2 (VERTREP)	HAC	CARGO 2
SHIP 3 (NITE LANDINGS)	HAC	SHIP 1, NITE 1 & 2
SHIP 4 (NITE VERTREP)	HAC	SHIP 2, CARGO 3
WATER 1 (H20 LANDING)	WATER INSTRUCTOR	
WATER 2 (H20 HOIST)	HAC	
NATOPS REVIEW	INSTRUCTOR/ANI	COMPLETED SYLLABUS
NATOPS EVALUATION	ANI	NATOPS REVIEW

Table I: General Flight Syllabus

Modified syllabus for second tour pilots previously qualified Helicopter Commander in the H-46 aircraft.

1.	FAM 0	2 HRS (NO FLY)
2.	FAM 1,2,3,4	5 HRS (3 HRS NO FLY)
3.	FAM 5,6	2 HRS
4.	FAM 7,8	2 HRS
5.	FAM 9,10	2 HRS
6.	INST 0	2 HRS (NO FLY)
7.	INST 1	2 HRS
8.	INST 2	2 HRS
9.	INST 3	2 HRS
10.	INST 4	3 HRS
11.	NIGHT 1	2 HRS
12.	NIGHT 2,3	2 HRS
13.	NAV 1	3 HRS
14.	NAV 2	3 HRS
15.	OP 0	2 HRS (NO FLY)
16.	CARGO 1,2	2 HRS
17.	CARGO 3	2 HRS
18.	SHIP 1,2	2 HRS
19.	SHIP 3,4	2 HRS
20.	WATER 1	1 HR
21.	WATER 2 COMBINED WITH FORM 1	2 HRS
22.	NATOPS CHECK	2 HRS

19 FLIGHTS

40 HOURS FLIGHT INSTRUCTION

9 HOURS GROUND INSTRUCTION

Table II: Modified Flight Syllabus

HC-3 Functional Check Pilot Training Syllabus

1. H-46 Systems Lectures:

   a. T58-GE-10
      Basic description
      Airflow
      Fuel supply
      Lubrication
      Fuel Control
      Engine condition control system
      PMS
      Emergency throttle

   b. Drive System
      High speed shaft
      Transmissions
      Sync shaft
      Vertical shaft
      Lubrication

   c. Flight Controls
      Basic installation
      Rigging checks
      Flight characteristics
      Rotor controls

   d. Automatic Flight Controls
      Speed trim
      SAS
      ASE

   e. Rotor System
      Rotor heads
      Rotor blades

   f. Structures
      Airframe
      Rotor blades
      Corrosion
      Stress/strain

   g. Auxiliary Power Plant

   h. Electrical System
      AC
      DC
      APP/GP
      Battery

Table III: FCF Syllabus

i. Hydraulics
Utility System #2 flight boost
Flight boost #1
Subsystems

2. Functional Check Pilot Syllabus

a. FCF 0 4 hours (no fly)

(1) Discuss:

(a) Publications

1 MIMS

2 OPNAV 4790.2, 3710.7

3 HC-3 1500.1

4 Pertinent HC-3 TIMIS

5 HC-3 SOP's

(2) Introduce:

(a) FCF Checklist

(b) Blade tracking

(c) Engine vibration checks

(d) Heavy hover

(e) Operation and installation of H-219

b. FCF 1 (2.0)

(1) Review:

(a) FCF Checklist

(2) Introduce:

(a) FCF Preflight

(b) Ground checks

(c) Engine checks

(3) Demonstrate:

(a) SAS and ASE checks in hover

Table III (Continued)

c. FCF 2 (2.0)

(1) Review previous maneuvers

(2) Introduce:

(a) Stick position checks

(b) SAS and ASE hover checks

(c) Speed trim, SAS, ASE in flight checks

d. FCF 3 (2.0)

(1) Review previous maneuvers

(2) Introduce:

(a) All additional flight checks

(b) Topping engines in flight

e. FCF 4 (2.0)

(1) Student performs all previous maneuvers

f. FCF 5 (2.0)

(1) Check student on all previous maneuvers

3. Functional Check Pilot Review Syllabus

a. H-46 Systems Review Course

b. FCF Checklist Review

c. 40 Question Closed Book Exam

Table III (Continued)

(1) IUT #1 - A lecture required for all HAC's and H2P's within 20 hours of HAC, to include the following:

(a) Importance of program

(b) Description of program

(c) Responsibilities for pilot training

(d) Basic fundamentals of teaching and learning

(e) Application to syllabus and non-syllabus hops

(f) Techniques for simulating and discussing emergencies

(g) Evaluations and critiques

(2) IUT #2 - A lecture required for all Instructor Pilots (IP's)

(a) Definition and necessity for instructor pilots

(b) Instructional techniques for solving problem areas

(3) IUT #3 - A 3.0 hour flight required for Instructor Pilots

(a) Brief - Techniques for conducting training/check flight brief.

(b) Flight - Detecting and correcting inflight discrepancies.

(c) Debrief - Debriefing/evaluating all flights

Table IV: IUT Syllabus

TOTAL OPERATING COST PER AIRCRAFT PER YEAR	ESTIMATED HOURS PER AIRCRAFT PER MONTH	COST PER FLIGHT HOUR
$628,000	30.00	$1,744.00

Table V: Average Cost Per Flight Hour

SYLLABUS	HOURS FLOWN	TOTAL FLYING COSTS
GENERAL	57	$ 99,408
MODIFIED	40	$ 69,760
FCF	8	$ 13,952
IUT	3	$ 5,232

Table VI: Average Flying Costs Per Syllabus

B. PROPOSED TRAINING SYLLABUS

1. ISD (Instructional Systems Design)

An ISD approach to developing a training program is essentially a common sense approach to training. The ISD model will assist the training officer to establish strategies for carrying out the analysis, design, development, implementation, and quality control of HC-3's training program. It must be kept in mind that ISD is a complex process, therefore, the available resources and time constraints imposed on this present effort will not allow an indepth application of the ISD model to the proposed HC-3 training program. All that can hope to be accomplished is to point out those principles of the ISD model necessary to construct an efficient training program.

Probably the most crucial step in building an ISD model is analysis. The analysis phase couples the techniques of modern psychology and technology of instructional systems, in order to approach training based on the science of human behavior. A task analysis is the tool used to determine the tasks that must be performed to operate the system, and under what conditions these tasks are performed. It is only through understanding the task to be performed, including its characteristics, that one can hope to understand operator or system behavior, and it is in this respect that a task analysis is so crucial.

A task analysis describes in a detailed and standardized fashion the primary task components that must be

performed. This task analysis defines the precise conditions under which the task is performed, the action which make up the performance, and the associated outcomes of the performance. Through this task identification and description a more accurate understanding of the behavior required in the task will evolve, which will lead hopefully to more efficient training [Funaro, 1978]. After generating the descriptive statements of conditions, actions and outcomes of task components, a job description known as a task listing is formed. This task listing provides a visualization of the behavior required to perform a specific task.

To ensure that task descriptions are accurate and that the task list is complete, a task validation is conducted. During this validation phase, estimates of the frequency and criticality of tasks are made in order to determine the level of training required. Also, the attributes of the task which makes the task essential to the training program are examined. These essential attributes of a task are:

1. What are the task prerequisites?
2. What is the task's sequential interdependence with other tasks?
3. What key function does the task play in completion of a mission?

Major benefits are achieved as a result of a carefully conceived task analysis. Time and resources are not wasted

needlessly on unnecessary training, and essential tasks, critical to competent performance, are not overlooked. A better understanding as to which environment, simulated (part of whole-task trainer), or real, will lend itself to the most efficient training of the task, is another possible benefit of a task analysis. Just that level of training necessary to meet operational standards will also evolve out of a well conceived task analysis.

The ISD process goes somewhat further in the task analysis to determine the nature of behavioral objectives which the training program must be designed to achieve. Funaro (1978) has indicated that the distinction between tasks and behavioral objectives is fundamental to the ISD methodology. The distinction is that tasks are what a person must do to operate a system, whereas behavioral objectives are what a training program must achieve to produce a competent task performance. These behavioral objectives are ordered in an objective hierarchy where intermediate behavior are prerequisite to target behaviors, which are prerequisite to whole task performance. Again the whole driving force behind the behavioral hierarchy is to make more explicit that which must be trained.

2. Personnel

To aid in the effectiveness of HC-3's training, instructors and trainees must be indoctrinated and become fully acquainted with the rationale that has led to the specific manner in which device 2-F117B is incorporated into

the training program. They should understand why the OFT is employed to train certain flight tasks and not others. This indoctrination allows both the instructor and trainee to see the use of the simulator as an integrated part of the whole program. This whole program approach will prevent the training program from becoming segmented into parts that do not interact smoothly. The end result will allow instructors to have better communication with their students on how respective parts of the program integrate to form the whole.

The ISD process would suggest a need to expand HC-3's present IUT syllabus. To have an effective training program it is necessary to insure that not only does the program have explicit instructor selection criteria, but that once selected, the instructor should gain a thorough understanding of training principles required for effective simulator and aircraft utilization. The IUT syllabus must also foster the instructor's motivation in the role he must perform. As mentioned earlier, instructor's attitudes influence the trainee, and as an end result may either increase or decrease effectiveness of the entire training program.

3. Proposed Syllabus

The proposed HC-3 flight syllabus presented in this paper will be constructed from theoretical observation presented in the flight training literature. Holman (1979) did extensive research of the training effectiveness on the CH-47 flight simulator in order to determine which flight

tasks the simulator could effectively train. Table 7 summarizes CTERs for various maneuvers and will be used as a basis to determine which maneuvers should be trained in the H-46 simulator. Cumulative Transfer Effectiveness Ratio (CTER) is the same formula as TERs presented in an earlier section. CRT 6 and 8 are criterion performance levels, based on a 12 point scale, established to evaluate each maneuver. "Unsatisfactory" performance is rated 1 through 3, "fair" is rated 4 through 6, "good" is rated 7 through 9, and "excellent" is rated 10 through 12 [Holman, 1979]. A number of theoretical observations, some discussed earlier, will also aid in the rationale for HC-3's proposed training program. These observations will be summarized as follows:

1. Simulators train best in precise procedural tasks, e.g., instruments, approaches and landings.
2. Instructors should instruct in both the simulator and the aircraft.
3. Cycle the trainee from ground school, to part-task trainer (as needed) to OFT, to aircraft throughout the program. This cycling maintains integrity in the training program and allows practice of newly acquired skills as soon as possible.
4. Part-task trainers utilized in conjunction with simulators provide for more efficient training.

It must be remembered that this proposed training program needs to be a dynamic one. Time must be taken to

CUMULATIVE TRANSFER EFFECTIVENESS RATIO (CTER) BY MANEUVER FROM THE CH47FS TO THE CH-47 AIRCRAFT

	CTERs Trials to Criterion		CTERs Time	
Maneuver	Crt 6	Crt 8	Crt 8	Total
General Airwork	.69	1.00	1.08	-.13
Cockpit Runup	1.00	1.50	1.08	1.36
Four Wheel Taxi	1.40	2.80	2.96	1.69
Two Wheel Taxi	1.14	1.00	.81	.75
Takeoff to Hover	.53	.63	.57	.61
Hovering Flight	.58	.79	.73	.57
Landing from Hover	.56	.69	.65	.47
Normal Takeoff	.60	.75	.60	.38
Traffic Pattern	.56	.61	.76	.72
Deceleration	1.00	1.25	1.25	1.08
SAS Off Flight	1.00	1.33		
Normal Approach	.65	.53	.60	.58
Maximum Takeoff	.88	1.25	1.24	.67
Steep Approach	.80	1.00	.98	.80
Shallow Approach	.50	.58	.60	.33
Confined Area Recon	.75	1.00	1.59	.80
Confined Area Approach	.50	.75	.25	-.23
Confined Area Takeoff	.50	.50	.63	.33
External Load Briefing	1.00	.67	.92	.58
External Load Takeoff	.50	.50	1.66	1.62
External Load Appraoch	.50	.50	.76	.50
Pinnacle Recon	1.00	.50	.71	.09
Pinnacle Approach	.67	.00	-.28	-.43
Pinnacle Takeoff	.67	.33	.26	.06
Overall CTER	.69	.82	.95	.70

Table VII: CTERs For Various Tasks in the CH-47

use the simulator and training program experimentally. Here, by using appropriate experimental design and control, a credible data base can be formed with which to validate the training program at a future date.

It will be assumed in this report that the visual system on device 2-F117B will provide ample visual fidelity to allow effective training in hovering type tasks. Many present helicopter simulators lack the visual ground references, at very low altitudes, needed in the visual system. It is in this flight regime that many flight tasks in a helicopter are performed, and the need for an adequate visual system is paramount.

Tables VIII, IX, X and XI will give proposed flight training syllabi (with and without a visual system) for the general, and modified, as well as, the FCF and IUT syllabi. A complete description of the general syllabus will be given in Appendix B.

Table 12 summarizes hours, costs, percent savings, and TER's for the different syllabi proposed. A trend is apparent where increased utilization of the simulator will result in decreased costs per pilot per syllabus. When the simulator is not equipped with a visual system, it will not be utilized in the FCF syllabus, therefore, the costs and hours will be the same as the original program. The costs of the IUT syllabus will increase slightly in both cases (visual and no visual) the reason being that there is no substitution of simulator time for aircraft time. The aircraft

SYLLABUS FLIGHTS	TRAINING DEVICE	HOURS
FAM 1	NO FLIGHT	2.0
FAM 2	NO FLIGHT	2.0
FAM 3	PT AND A/C	2.0
FAM 4	OFT AND A/C	3.0 (1 hr no-fly)
FAM 5	OFT AND A/C	3.0 (1 hr no-fly)
FAM 6	OFT	2.0
FAM 7	A/C	2.0
FAM 8	OFT	2.0
FAM 9	OFT	2.0
FAM 10	A/C	2.0
FAM 11	A/C	2.0
FAM 12	OFT	2.0
INST 0	NO FLIGHT	4.0
INST 1	OFT	2.0
INST 2	OFT	2.0
INST 3	OFT	2.0
INST 4	A/C	4.0
NIGHT 1	A/C	2.0
NIGHT 2	A/C	2.0
NIGHT 3	A/C	2.0
NAV 1	A/C	3.0
NAV 2	OFT	3.0
OP 0	NO FLIGHT	4.0
CARGO 1	OFT	2.0
CARGO 2	OFT	2.0
CARGO 3	A/C	2.0
SHIP 1	OFT	1.0
SHIP 2	A/C	1.0
SHIP 3	OFT	1.0
SHIP 4	A/C	1.0
WATER 1	A/C	1.0
WATER 2	A/C	1.0
FORM 1	OFT	1.0
NATOPS 1	OFT	2.0
NATOPS CHECK	A/C	2.0

GROUND SCHOOL	14
OFT HOURS	28
A/C HOURS	29
TOTAL	71

(PT) PROCEDURAL TRAINER
(A/C) AIRCRAFT

Table VIII: General Syllabus (with visual)

SYLLABUS FLIGHT	TRAINING DEVICE	HOURS
FAM 1	NO FLIGHT	2.0
FAM 2	NO FLIGHT	2.0
FAM 3	PT AND A/C	2.0
FAM 4	A/C AND OFT	3.0 (1 hr no-fly)
FAM 5	A/C	3.0 (1 hr no-fly)
FAM 6	A/C	2.0
FAM 7	A/C	2.0
FAM 8	A/C	2.0
FAM 9	OFT	2.0
FAM 10	A/C	2.0
FAM 11	A/C	2.0
FAM 12	A/C	2.0
INST 0	NO FLIGHT	4.0
INST 1	OFT	2.0
INST 2	OFT	2.0
INST 3	OFT	2.0
INST 4	A/C	4.0
NIGHT 1	A/C	2.0
NIGHT 2	A/C	2.0
NIGHT 3	A/C	2.0
NAV 1	A/C	3.0
NAV 2	A/C	3.0
OP 0	NO FLIGHT	4.0
CARGO 1	A/C	2.0
CARGO 2	A/C	2.0
CARGO 3	A/C	2.0
SHIP 1	A/C	1.0
SHIP 2	A/C	1.0
SHIP 3	A/C	1.0
SHIP 4	A/C	1.0
WATER 1	A/C	1.0
WATER 2	A/C	1.0
FORM 1	A/C	1.0
NATOPS CHECK	A/C	2.0

GROUND SCHOOL	14
OFT HOURS	10
A/C HOURS	47
TOTAL	71

Table VIII (Continued)

General Syllabus (Without Visual)

SYLLABUS FLIGHT	TRAINING DEVICE	HOURS
FAM 1, 2, 3	NO FLIGHT	3.0
FAM 4, 5, 6	OFT	3.0
FAM 7	A/C	2.0
FAM 8, 9	OFT	2.0
FAM 10, 11	A/C	2.0
FAM 12, 13	A/C	2.0
INST 0	NO FLIGHT	2.0
INST 1	OFT	2.0
INST 2	OFT	2.0
INST 3	OFT	2.0
INST 4	A/C	2.0
NIGHT 1	A/C	2.0
NIGHT 2	A/C	2.0
NAV 1	A/C	3.0
NAV 2	OFT	3.0
OP 0	NO FLIGHT	2.0
CARGO 1, 2	OFT	2.0
CARGO 3	A/C	2.0
SHIP 1, 2	OFT	2.0
SHIP 3,4	A/C	2.0
WATER 1	A/C	1.0
WATER 1 FORM 1	A/C	2.0
NATIPS CHECK	A/C	2.0

GROUND SCHOOL	7
OFT HOURS	18
A/C HOURS	24
TOTAL	49

Table IX: Modified Syllabus (With Visual)

SYLLABUS FLIGHT	TRAINING DEVICE	HOURS
FAM 1, 2, 3	NO FLIGHT	3.0
FAM 4	OFT	2.0
FAM 5, 6	A/C	2.0
FAM 7, 8	A/C	2.0
FAM 9, 10	A/C	2.0
FAM 11, 12, 13	A/C	2.0
INST 0	NO FLIGHT	2.0
INST 1	OFT	2.0
INST 2	OFT	2.0
INST 3	OFT	2.0
INST 4	A/C	2.0
NIGHT 1	A/C	2.0
NIGHT 2, 3	A/C	2.0
NAV 1	A/C	2.0
NAV 2	A/C	2.0
OP 0	NO FLIGHT	2.0
CARGO 1, 2	A/C	2.0
CARGO 3	A/C	2.0
SHIP 1, 2	A/C	2.0
SHIP 3	A/C	2.0
WATER 1	A/C	1.0
WATER 2, FORM 1	A/C	2.0
NATOPS CHECK	A/C	2.0

GROUND SCHOOL	7
OFT HOURS	8
A/C HOURS	31
TOTAL	46

Table IX (Continued)

Modified Syllabus (Without Visual)

SYLLABUS FLIGHT	TRAINING DEVICE	HOURS
FCF 0	NO FLIGHT	4.0
FCF 1	OFT AND A/C	2.0 (No Flight)
FCF 2	OFT	2.0
FCF 3	OFT	2.0
FCF 4	A/C	2.0
FCF 4	A/C	2.0

GROUND SCHOOL	4.0
OFT HOURS	6.0
A/C HOURS	4.0
TOTAL	14.0

NOTE: FCF SYLLABUS (without visual) WILL BE THE SAME AS TABLE III

Table X: FCF Syllabus (with visual)

SYLLABUS FLIGHT	TRAINING DEVICE	HOURS
IUT 1	NO FLIGHT	8.0
IUT 2	NO FLIGHT	8.0
IUT 3	OFT	2.0
IUT 4	OFT	2.0
IUT 5	OFT	2.0
IUT 6	A/C	2.0

IUT Syllabus (with visual)

SYLLABUS FLIGHT	TRAINING DEVICE	HOURS
IUT 1	NO FLIGHT	8.0
IUT 2	NO FLIGHT	8.0
IUT 3	OFT	2.0
IUT 4	OFT	2.0
IUT 5	A/C	2.0

IUT Syllabus (without visual)

Table XI

AD-A078 266 NAVAL POSTGRADUATE SCHOOL MONTEREY CA F/G 5/9
A SYSTEMS APPROACH TO INTEGRATING THE H-46 OPERATIONAL FLIGHT T--ETC(U)
SEP 79 R D SMITH

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2 OF 2

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SYLLABUS	HOURS, A/C	HOURS, OFT	COST/PILOT	% SAVINGS	TER
GENERAL (no OFT)	57	0	$ 99,408	NA	NA
GENERAL (no visual)	47	10	$ 82,868	17.54	1.0
GENERAL (visual)	29	28	$ 53,096	49.12	1.0
MODIFIED (no OFT)	40	0	$ 69,760	NA	NA
MODIFIED (no visual)	31	8	$ 54,784	22.50	1.13
MODIFIED (visual)	24	18	$ 43,386	40.0	.89
FCF (no OFT)	8	0	$ 13,952	NA	NA
FCF (no visual)	8	0	$ 13,952	0	0
FCF (visual)	4	4	$ 7,336	50.0	1.0
IUT (no OFT)	3	0	$ 5,232	NA	NA
IUT (no visual)	3	4	$ 5,592	0	0
IUT (visual)	3	6	$ 5,772	0	0

Table XII: Hours, Costs, Percent Savings And TERs Between Different Syllabi

time is already minimal in the IUT syllabus and the addition of simulator flight time is needed to insure instructor understanding of the teaching techniques required in the simulator. TER is essentially a substitution ratio which indicates how much simulator time can be substituted for aircraft time. For the proposed syllabi the TERs are close to 1.0, therefore, one hour of H-46 OFT time can be substituted for one hour of H-46 helicopter time.

VIII. CONCLUSIONS AND RECOMMENDATIONS

As military aircraft weapon systems grow increasingly complex and sophisticated, the training requirements for personnel operating these weapon systems become correspondingly more demanding. Reducing costs associated with the training of personnel in present and future systems is the major driving force behind the utilization of flight simulators in many flight training programs. These modern simulators provide for a training environment that has never before been possible, allowing crew members to develop requisite skills safely, efficiently, and economically.

Recently, researchers and developers in the flight simulator community are approaching the complex task of designing and redesigning flight simulator and training methodologies to be responsive to training and/or learning. In past undertakings in the research and development of flight simulators, very little effort was expended in developing a technology of simulator training. This situation has hindered the development of a body of literature, where a generalized training model for simulators could be formulated. Consequently, very few if any training managers know how to train in simulators. Since a generalized flight simulator model does not presently exist, one might view the efforts in this report as somewhat idealistic. It must be kept in mind, though, that there are very few proven theories in existence on how to train in

simulators, therefore, one is left with an approach similar to the one presented in this paper.

Essentially, the wrong approach has been taken in many training programs. Presently, many training programs have been retrofited with simulators accompanied by training profiles to accommodate the simulator. The correct approach would be to first determine how much simulation was needed in the training program. Here, a trade-off analysis would be required on factors such as fidelity (motion, visual), efficiency, costs, technology, pilot motivation, and finally, the ability of the training program in providing aircrews who can perform adequately in the mission environment, and ultimately, in combat. In this approach, by applying the ISD methodology, those tasks that need to be trained will surface. A more in depth study of the task analysis will reveal those behaviors that must be modified to bring about the desired task performance. It is after this conceptual framework has been established, that the design of the simulator should be undertaken. It is only after understanding what behaviors must be modified that a simulator can be constructed to be responsive to these behavioral needs. With this approach the simulator becomes an integral part of the whole training program, instead of just a means to an end.

The proposed syllabus presented in this report will provide a basis from which to initially integrate device 2-F117B into HC-3's flight training syllabus. This report

will also provide the IUT school with an extensive reference of core topics (Benefits and Disadvantages of Simulation, Training/Learning Theory, Transfer Measures, and Fidelity of Visual and Motion Systems) from which to expand the IUT syllabus.

Time and funds must be initially committed to evaluate the OFT experimentally. This experimentation will provide a quantitative model from which to formulate training needs unique to HC-3's training program. Continued periodic evaluation of HC-3's training program is needed to maintain it in a dynamic state, and thereby make the training program responsive to future training needs.

APPENDIX A

SIMULATOR ADVANCED TRAINING FEATURES

Exercise Setup/Initialization

Exercise setups are preprogrammed conditions which initiate the simulator on predetermined attitudes, altitudes, velocity, heading and geographical location. Additionally, instruments readings as well as aircraft configurations are provided for in the training exercise. Considerations for the use of this feature are how many points are necessary to allow for instructor flexibility, and can learning principles, such as backward chaining, be utilized or does the feature simply provide a starting point in the training exercise.

Automatic Briefing

Automatic briefings are voice descriptions of maneuvers and procedures which include display and control information as well as performance criteria. This feature is synchronized with other automatic training features, e.g., automatic demonstration.

Automatic Demonstration

An automatic demonstration is an ideal task performance of aircraft maneuvers which are flown under computer control. It provides the student with a model of performance along with giving the instructor the means to present standardized examples of maneuvers.

Performance Oriented Guided Practice

This is a part-task learning feature where the computer retains control of one or more subtasks. This feature allows the student to develop some initial proficiency before tackling whole-task requirements.

Adaptive Training Exercises

Here complexity and/or difficulty of a task are tailored to the skill level of the trainee. This exercise is suited for brief, well-structured scenarios and integrated repetitive training requirements.

Non-Adaptive Training Exercises

Non-adaptive training exercises are complete or part-task maneuvers and/or procedures which are not modified or adapted to accommodate changes in trainee performance.

Preprogrammed Malfunction Insertion

Here simulated system emergencies are preselected to occur under specific conditions. Once initiated the gradual or abrupt failure occurs in the manner as if it were under instructor control.

Hardcopy Printout

Hardcopy printout provides a permanent record of trainee performance to aid in either training or evaluation. The parameters listed in the printout should be limited to relevant data amenable to training and interpretation by the instructor and student.

Maneuver Playback

This feature provides a temporary record of trainee performance, generally the last five minutes. Playback segments of varying time intervals repeat exact instrument readings, control movements, and motion and visual simulation. A synchronized voice recording plays back communications that occurred during the segment. The purpose of the maneuver playback is to provide self-confrontation for the trainee, and timely feedback for critiquing by the instructor.

Automated Performance Measurements

Performance data of the trainee are recorded and compared against predefined parameter tolerances. Here quantitative performance data can be used either to supplement subjective performance ratings or provide manipulation of adaptive training situations.

Freeze

This feature is used to immediately freeze all simulator systems in order to point out student errors, to draw student attention to various flight environments, or to terminate the training segment.

APPENDIX B

PROPOSED GENERAL FLIGHT SYLLABUS

FAM 1	NO FLIGHT	2.0 hrs

APPROPRIATE DIRECTIVES

OPNAV 3710.7 SERIES
NATOPS MANUAL
HC-3 TRAINING MANUAL
SOP's

SYLLABUS

HC-3 TRAINING MANUAL
DESIGNATION QUALIFICATIONS

FAM 2	NO FLIGHT	2.0 hrs

SYLLABUS

CURRENT FLIGHT TRAINING PROGRAM
TRAINEE PREPARATION
GRADING SYSTEM
PROGRAM CONTENT
OFT UTILIZATION
HAD/IP CRITQUE

FAM 3	PROCEDURAL TRAINER/ AIRCRAFT	2.0 hrs

INTRODUCE

PREFLIGHT (A/C)
APP START
START SEQUENCE THROUGH FOTOR ENGAGEMENT
PILOT/DIRECTOR HAND SIGNALS
SHUTDOWN COCKPIT PROCEDURES

FAM 4 OFT/AIRCRAFT 3.0 hrs

REVIEW

PREFLIGHT (A/C)
APP START
START SEQUENCE THROUGH
ROTOR ENGAGEMENT
PILOT DIRECTOR HAND
SIGNALS
SHUT DOWN

INTRODUCE

APP COMPARTMENT FIRE
HOT START
ENGINE COMPARTMENT FIRE
ECA FAILURE
FUSELAGE FIRE ON GROUND
COMPRESSOR STALL ON START
ECA FAILURE ON SHUTDOWN

FAM 5 OFT/AIRCRAFT 3.0 hrs

REVIEW

PREFLIGHT -- CHECK SAFE
FOR INDEPENDENT PREFLIGHT
POSTFLIGHT
APP START
START SEQUENCE THROUGH
ROTOR ENGAGEMENT
GROUND CHECKS
SHUT DOWN
PREVIOUS EMERGENCIES

INTRODUCE

EMERGENCY THROTTLE SYSTEM
IN DEPTH
DITCHING AND EGRESS
PROCEDURES

FAM 6 OFT 2.0 hrs

REVIEW

FAM 1, 2, 3, PROCEDURES
AND EMERGENCIES

INTRODUCE

COURSE RULES/AREA CHECK OUT
TAXING
VERTICAL TAKEOFF AND LANDING
HOVERING
FORWARD, SIDEWARD, REARWARD FLIGHT
TRANSITION TO FORWARD FLIGHT
NORMAL APPROACH
FUEL, COMPASS, CAUTION LITE CHECKS

FAM 7 AIRCRAFT 2.0 hrs

REVIEW

PREVIOUS MANEUVERS

INTRODUCE

BLADE UNFOLD AND FOLD

DEMONSTRATE

AIRCRAFT MANEUVERING E.G., VERTREP APPROACH, MAX ANGLE OF BANK, ATS AND ALT HOLD OPERATIONS.

DISCUSS

LOST COMM/ELECTRICAL FAILURE NAS NORIS AND HALF I.B.

FAM 8 OFT 2.0 hrs

REVIEW

SELECTED PREVIOUS EMERGENCIES AND MANEUVERS

INTRODUCE

SAS OFF FLIGHT
RUNNING TAKE OFF
RUNNING LANDING
SINGLE ENGINE FLIGHT, APPROACH TO RUNWAY

INTRODUCE EMERGENCIES

ELECTRICAL FIRE
SINGLE AND DUAL SAS FAILURE
GENERATOR FAILURE
COMPLETE ELECTRICAL FAILURE
FLEX SHAFT FAILURE
PMS FAILURE

FAM 9	OFT	2.0 hrs

INTRODUCE

STRAIGHT IN AUTOROTATION (1000' and 500')
EMERGENCY THROTTLE OPERATION
PMS OPERATION
BEEP TRIM SWITCHES
MAX GLIDE AUTO

INTRODUCE EMERGENCIES

ENGINE FAILURE ON TAKE OFF
FAILURE OF ONE ENGINE INFLIGHT
COMPRESSOR STALL INFLIGHT
SPRAG CLUTCH FAILURE
SINGLE ENGINE LANDING TO PAD
MAIN ENGINE RESTART INFLIGHT

DISCUSS

IMMINENT TRANSMISSION FAILURE
HYDRAULIC FLIGHT CONTROL FAILURE
UTILITY HYDRAULIC FAILURE
UTILITY HYDRAULIC HOT LIGHT

FAM 10	AIRCRAFT	2.0 hrs

REVIEW

PREVIOUS MANEUVERS

INTRODUCE

90 DEGREE AUTOS (1000' and 500')
PRACTICE EMERGENCY THROTTLE TO RUNWAY

SHUT DOWN WITHOUT APP POWER
CROSSFEED OPERATION

DISCUSS

LOW FUEL STATE
ENGINE COMPARTMENT FIRE INFLIGHT
FUSELAGE FIRE INFLIGHT
FUEL BOOST PUMP FAILURE
SMOKE AND FUME ELIMINATION
PREVIOUS EMERGENCIES

FAM 11 AIRCRAFT 2.0 hrs

INTRODUCE

MAX LOAD TAKE OFF FROM PAD AREA
MAX LOAD LANDING TO PAD AREA
CONFINED AREA APPROACHES
EMERGENCY THROTTLE TO PAD

REVIEW

PREVIOUS MANEUVERS AND EMERGENCIES AS NEEDED

FAM 12 OFT 2.0 hrs

REVIEW

ALL PREVIOUS MANEUVERS
  WITH EMPHASIS ON
  SINGLE ENGINE OPERATION
  AUTOROTATIONS
  EMERGENCY THROTTLE OPERATIONS
  COMPLETE ELECTRICAL FAILURE

INTRODUCE

VARIOUS SPEED TRIM MODES
LOST COMM TO NORTH ISLAND
SHUTDOWN WITHOUT BATTERY POWER

DISCUSS

ALL ITEMS ON MASTER CAUTION PANEL
SPEED TRIM ACTUATOR FAILURE
ECA FAILURE IN FLIGHT

FAM 13 AIRCRAFT 2.0 hrs

CHECK RIDE

EVALUATE ALL PREVIOUS MANEUVERS AND EMERGENCIES TO DETERMINE CAPABILITY TO CONTINUE WITH SYLLABUS

INSTRUMENT STAGE

INST 0 NO FLIGHT 4.0 hrs

DISCUSS

PREREQUISITES
HOP DESCRIPTION
BI PATTERNS
CONTROL AND PERFORMANCE INSTRUMENTS
ESSENTIAL EQUIPMENT
TECHNIUES AND PROCEDURES
COMNAVIDENT EQUIPMENT CAPABILITIES AND DESCRIPTION
FLIGHT PLANNING, PERFORMANCE CHARTS, FUEL MANAGEMENT,
  H-46 COMPUTER
NITE FLYING
  NITE HOP DESCRIPTIONS
  NITE LIGHT SIGNALS
VFR FLYING
  DR NAV
  MOUNTAIN FLYING

INST 1 OFT 2.0 hrs

INTRODUCE

BASIC INSTRUMENT AT ALTITUDE
LEVEL FLIGHT WITH SPEED CHANGES
TIMED TURNS
CLIMBS AND DESCENTS
S-1 PATTERN
TURN PATTERN
PARTIAL PANEL
UNUSUAL ATTITUDES
ATS AND ALT HOLD ON AND OFF

DISCUSS

CREW COORDINATION
MANEUVER LIMITS
RMI PRECESSION
INFREQUENTLY USED SWITCHES
HELICOPTER OFFSHORE TRAINING AREA PROCEDURES
INSTRUMENT SCAN

INST 2 OFT 2.0 hrs

INTRODUCE

INSTRUMENT TAKEOFF
OSCAR PATTERN
LOW LEVEL INSTRUMENT OVER THE WATER
RADAR ALTIMETER FAILURE DURING LOW LEVEL INSTRUMENT FLIGHT
OVER WATER HOVER PRACTICE
NIGHT/LOW VISIBILITY/HIFR APPROACH TO BUOY OR SMOKE LIGHT

REVIEW

ALL PREVIOUS INSTRUMENT MANEUVERS
PARTIAL PANEL

DISCUSS

CREW COORDINATION
MANEUVER LIMITS

INST 3 OFT 2.0 hrs

INTRODUCE

TACAN APPRAOCHES
GCA APPROACHES (NO GYRO AND EMERGENCY DESCENT)
ADF APPROACHES
TACAN POINT TO POINT
HOLDING PROCEDURES
UHF ADF ORIENTATION
FM HOMING
ASR APPROACHES

REVIEW

INSTRUMENT TAKEOFF

DISCUSS

TACAN AIR TO AIR
HF
IFF
UHF
ADF

INST 4 AIRCRAFT 4.0 hrs

INTRODUCE

CROSS-COUNTRY IFR FLIGHT
INTERNAL TANK OPERATION
CLEARANCE RECEIPT
CLEARANCE COMPLIANCE
CONDUCT OF FLIGHT
INSTRUMENT APPROACHES
FLIGHT PLANNING (DD 175, JET LOG)

DISCUSS

LOST COMM/NAV GEAR
FUEL, COMPASS, AUTION PANEL CHECKS
SPEED TRIM/BOOST PUMPS ABOVE 60000'

NIGHT 1 AIRCRAFT 2.0 hrs

INTRODUCE

LIGHT SIGNALS FOR NIGHT TURN-UP AND SHUTDOWN
TAKEOFFS AND LANDINGS
PAD APPREACHER
RUNWAY APPROACHES
NIGHT AUTOROTATIONS
SINGLE ENGINE LANDINGS TO RUNWAY
SAS OFF FLIGHT
ETS OPERATION
SEARCH AND HOVER LIGHT OPERATION

REVIEW

TOTAL ELECTRICAL FAILURE AND LOST COMM FOR NORIS AND HALF I.B.
SINGLE ENGINE PROCEDURES
EMERGENCY THROTTLE PROCEDURES

NIGHT 2 AIRCRAFT 2.0 hrs

INTRODUCE

NON-PRECISION APPROACHES
PRECISION APPROACHES
LOW LEVEL INSTRUMENTS

REVIEW

ALL NIGHT 1 MANEUVERS

DISCUSS

CREW COORDINATION
MANEUVER LIMITS

NIGHT 3 AIRCRAFT 2.0 hrs

REVIEW

PAD APPROACHES
RUNWAY APPROACHES
AUTOROTATIONS
LOW LEVEL INSTRUMENTS OVER WATER
PRECISION APPROACHES
NON-PRECISION APPROACHES

DISCUSS

SPRAG CLUTCH FAILURE
IMMINENT TRANSMISSION FAILURE
DITCHING

NAV 1 AIRCRAFT 2.0 hrs

INTRODUCE

VFR FLIGHT (OFF AIRWAYS/LOW LEVEL)
ROUGH TERRAIN FLIGHT
MOUNTAIN PAD APPROACHES
HC-3 VFR NAV ROUTE
INTERNAL TANK OPERATION

DISCUSS

VFR SECTIONALS
VFR FLIGHT PLANNING (DD 175 and JET LOGS)
VFR TOWER TO TOWER FLIGHTS
HELO TRAINING AREA
NATOPS MOUNTAIN AND ROUGH TERRAIN SECTION
FLIGHT AND PERFORMANCE COMPUTERS
POSITIVE CONTROL POLICY

NAV 2 OFT 3.0 hrs

INTRODUCE

DR NAVIGATION OVER WATER
MK 6 PLOTTING BOARD UTILIZATION

DISCUSS

SINGLE ENGINE PROCEDURES
SINGLE ENGINE TAKE-OFF FROM WATER
EMERGENCY LANDING ON WATER
AUTOROTATION TO WATER
LOW FUEL STATE OVER WATER

TACAN, ADF ORIENTATION
LF/DF, UHF/DF AND FM HOMING PROCEDURES

REVIEW

SQUADRON SOP's

OPERATIONAL STAGE

OP 0	NO FLIGHT	4.0 hrs

DISCUSS

EXTERNAL CARGO AND HOISTING METHODS, TECHNIQUES AND EQUIPMENT
PERTINENT PUBLICATIONS, E.G., NWP 42, NWP 38, NATOPS MANUAL, NOSTAC
FLIGHT DECK MARKINGS AND LIGHTING
CREW COORDINATION
FORMATION TACTICS
WATER LANDINGS
HIFR

CARGO 1	OFT	2.0 hrs

INTRODUCE

CARGO HOOK INSTALLATION
CARGO HOIST TECHNIQUES
CARGO OPERATIONS ON PAD (1000-25000 lbs loads)
HOIST OPERATIONS WITH SIMULATED PICKUPS
PROCEDURES FOR HANDLING OSCILLATING LOADS
CREW COORDINATION
RAMP AND HATCH OPERATION

DISCUSS

VERTREP AND EXTERNAL CARGO SECTIONS OF NATOPS MANUAL
OPERATION OF ELECTRICAL AND EMERGENCY CARGO HOOK RELEASE

REVIEW

SINGLE ENGINE OPERATION (WITHOUT LOAD)

CARGO 2	OFT	2.0 hrs

INTRODUCE

HEAVY LOADS (4000 lb)
LOST ICS PROCEDURES

TECHNIQUES FOR HANDLING LIGHT LOADS
SIMULATED PERSONNEL HOIST OPERATIONS (UTILIZING OSCAR DUMMY IF AVAILABLE)

REVIEW

CARGO 1 MANEUVERS (1000-2500 lbs loads)

CARGO 3	AIRCRAFT	2.0 hrs

REVIEW

PERSONNEL HOIST OPERATIONS (SIMULATED)
CARGO OPERATIONS ON PAD (1000-2500 LBS LOAD)
NIGHT PILOT/DIRECTOR LIGHT SIGNALS
LOST ICS PROCEDURES

SHIP 1	OFT	1.0

INTRODUCE

SHIPBOARD TAKEOFF AND LANDING

DISCUSS

SHIPBOARD TECHNIQUES, HAZARDS, SAFETY
EFFECTS OF WIND FLOW AROUND SHIP
INFLIGHT REFUELING (HIFR)
SINGLE ENGINE LANDING TO A SHIP
HELICOPTER OPERATING AND SUPPORT FACILITIES BULLETIN NO. 1 SERIES
AVAIATION FACILITIES SHIPS HELICOPTER FACILITY RESUME
NOSTAC
HELICOPTER FACILITY CERTIFICATION STATUS REPORTS
NWP 42 SHIPBOARD HELICOPTER OPERATING PROCEDURES
APPROPRIATE NATOPS MANUAL SECTION

REVIEW

EMERGENCY LANDING ON WATER
DITCHING
SINGLE ENGINE TAKEOFF FROM WATER

SHIP 2	AIRCRAFT	1.0

INTRODUCE

VERTICAL REPLENISHMENT
CREW COORDINATION
ICS VOICE PROCEDURES

DISCUSS

NWP 42 SHIPBOARD HELICOPTER OPERATING PROCEDURES
NWP 38 REPLENISHMENT AT SEA, CHAPTER 9
APPROPRIATE SECTIONS OF NATOPS MANUAL
OPERATIONS IN SALT WATER ENVIRONMENT

REVIEW

ALL ITEMS DISCUSSED ON SHIP 1
LOST ICS PROCEDURES

SHIP 3 OFT 1.0 hrs

INTRODUCE

NIGHT SHIPBOARD TAKEOFF AND LANDING
TRANSITION BETWEEN VISUAL SCAN AND INSTRUMENT SCAN

DISCUSS

SHIP DECK LIGHTING
NIGHT PILOT/DIRECTOR LIGHT SIGNALS
SHIPBOARD PROCEDURES

SHIP 4 AIRCRAFT 1.0 hrs

INTRODUCE

NIGHT VERTREP

DISCUSS

EMPHASIZE VERTREP TECHNIQUES AND DIFFICULTIES PECULIAR TO NIGHT OPERATIONS

REVIEW

OVERWATER EMERGENCIES
SHIPBOARD PROCEDURES
CREW COORDINATION
ICS VOICE PROCEDURES

WATER 1 AIRCRAFT 1.0 hrs

INTRODUCE

VERTICAL LANDING AND TAKEOFF
APPROACHES TO WATER
RUNNING LANDING AND TAKEOFFS

WATER TAXING
VARIOUS SPEED TRIM MODES
SIMULATED SINGLE ENGINE APPROACHES TO WATER
SIMULATED SINGLE ENGINE TAKEOFF WATER

<u>DISCUSS</u>

AUTOROTATIONS TO WATER
DITCHING
WATERTIGHT INTEGRITY
USE OF EMERGENCY UHF ANTENNA
STRIP CHECKLIST

WATER 2	AIRCRAFT	1.0 hrs

<u>INTRODUCE</u>

HOIST OPERATIONS OVER WATER
CREW COORDINATION
HOVERING OVER WATER TECHNIQUES

<u>DISCUSS</u>

H-46 HOISTING POINTS
LOST ICS DURING HOISTING
SALT WATER ENVIRONMENT OPERATIONS
SINGLE ENGINE PROCEDURES

FORM 1	OFT	1.0 hrs

<u>INTRODUCE</u>

FORMATION FLIGHT TECHNIQUES
RUNNING JOIN-UP
CROSSOVERS
PARADE TURNS
LEAD CHANGES
SECTION GCA

<u>DISCUSS</u>

FORMATION SECTION OF MATOPS MANUAL
LOST COMMUNICATIONS
INADVERTANT IFR PROCEDURES

NATOPS 1	OFT	2.0 hrs

PRE-CHECKRIDE

NATOPS 2	AIRCRAFT	2.0 hrs

CHECK RIDE

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